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D 1135 in the Argentine

In a recent report of the Argentine Sugar Experiment Station, by Dr. William C. Cross, Director, several statements are made which are of interest to us here in Hawaii.

Referring to D 1135 he has this to say:*

The experiments with this variety have been continued in five different plots. The last two years' results have been in general quite good, although it is proven that this cane is not as good as the P. O. J. 36 and 213. Although in the beginning it showed considerable resistance to mosaic disease, in the last two years it has been more attacked by the pest than the Java canes. In conclusion we may say that this variety has not turned out to be as valuable as it promised to be at first and cannot be recommended in preference to the Java varieties generally planted.

The Java canes which he mentions, P. O. J. 36 and 213, have now been distributed to all plantations here which desired to try them out, and we are in a splendid position to spread them rapidly should they prove to be superior to D 1135 here.

In connection with two other Java canes which we have here, now growing in quarantine, P .O. J. 2714 and 2725, Dr. Cross has the following to say:

P. O. J. 2714: This is another variety which is considered immune (or almost immune) to the mosaic disease in Java, where it is cultivated to a total extension of some 70,000 acres. In that country it is a cane of excellent yields of cane and sugar per hectare, having also a fairly high fiber content (average 12.5 per cent). Its stalks are thick and heavy, yellowish brown in color. Here we have had it under experimentation only a short time and on a small scale as yet, but it appears to promise well. One analysis of the plant cane made very early in the grinding season (May 17, 1923) gave the following results: Brix, 12.97 per cent; sucrose, 9.03; purity, 69.62. We have no tonnage results as yet, but its appearance in the field is promising.

P. O. J. 2725: This variety is also considered immune, or almost immune, to the mosaic disease in Java, where many of the factories cultivate it in a small way, the total extension in 1922 being over five thousand acres. It is a green cane of thick stalk, very vigorous in growth and of satisfactory sugar content. Of all these varieties which are immune, or almost immune, to the mosaic disease it is the one which up to now promises to give the best results in this country. We have three plots of this variety. One on a small scale, established in 1920 (plot C); another planted in 1921 (plot A), and the third in 1922 (plot B).

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* From *Facts About Sugar*, May 23, 1925, p. 499.

In view of its good production of cane and sugar per acre, its great resistance to the mosaic disease, and its general properties of being a thick, heavy cane, easy to strip and cheap to transport to the mill, we consider that this cane is one of the most promising of the new varieties which this institution possesses. We have already established with this cane a number of cooperative experiments in the lands belonging to the factories in various parts of the country, and up to now the opinion of everyone respecting this variety is quite favorable.

[J. A. V.]

Present Fertilizer Practices on the Sugar Plantations of the Hawaiian Islands*

By J. A. Verret

First of all the committee desires to thank the plantations for their splendid cooperation in this work. Thirty-eight replies to the questionnaires sent out were received. All the plantations on Oahu and Maui replied, and all but two on Hawaii. Kauai made the poorest showing with no replies from three.

Mixed Fertilizers

From the replies received we find that 19 different formulas are used on 34 plantations. Four of the plantations reporting do not use ready mixed fertilizers. Of these four, two use nitrogen only, another of them uses superphosphate in addition to nitrogen on the upper fields, while a fourth uses bonemeal and potash from molasses ash, in addition to nitrogen as field tests show their need on different fields.

The different formulas used, their approximate make-up, the pounds of filler and the number of plantations using them are listed below:

No.	Formula		Pounds per Ton	No. of Plantations Using
1.				
	12% N.......	5% Ammo. Sulph.	488 lbs. Ammo. Sulph.	5
		6% Nit. Potash	857 lbs. Nit. Potash	
		1% Organic	210 lbs. Superphos.	
			273 lbs. Bone meal	
	$5\%\ P_2O_5$.....	2% Superphos.	160 lbs. Sulph. or Muriate Potash	
		3% Bone meal	12 lbs. filler	
	$10\%\ K_2O$....	6% Nit. Potash		
		4% Sulph. or Muriate Potash		
2.				
	12% N.......	5½% Ammo. Sulph.	537 lbs. Ammo. Sulph.	1
		6% Nit. Potash	857 lbs. Nit. Potash	
		½% Organic	273 lbs. Bone meal	
			160 lbs. Sulph. Potash	

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

3% P_2O_5.....	Bone meal	173 lbs. filler	
10% K_2O....	4% Sulph. Potash 6% Nit. Potash		

3.

11% N.......	10% Nit. Soda 1% Organic	1,200 lbs. Nit. Soda 273 lbs. Bone meal 360 lbs. Sulph. or Muriate Potash	1
3% P_2O_5.....	Bone meal	77 lbs. filler	
9% K_2O.....	Sulphate or Muriate?		

3A. Another same as above except no phosphoric acid.

4.

11% N.......	4½% Ammo. Sulph. 6% Nit. Potash ½% Organic	439 lbs. Ammo. Sulph. 857 lbs. Nit. Potash 158 lbs. Superphos. 136 lbs. Bone meal	1
3% P_2O_5.....	1½% Superphos. 1½% Bone meal	40 lbs. Sulph. Potash 370 lbs. filler	
7% K_2O.....	Pot. Nit. and Sulph.		

5.

11% N.......	6% Nit. Potash 4% Ammo. Sulph. 1% Organic	857 lbs. Nit. Potash 390 lbs. Ammo. Sulph. 316 lbs. Superphos. 273 lbs. Bone meal	6
6% P_2O_5.....	3% Superphos. 3% Bone meal	167 lbs. filler	
6% K_2O.....	Pot. Nitrate		

6.

11% N.......	4½% Ammo. Sulph. 6% Nit. Potash ½% Organic	439 lbs. Ammo. Sulph. 857 lbs. Nit. Potash 316 lbs. Superphos. 273 lbs. Bone meal	1
6% P_2O_5.....	3% Superphos. 3% Bone meal	115 lbs. filler	
6% K_2O.....	Potash Nit.		

7.

12% N......	5½% Nit. Potash 6% Ammo. Sulph. ½% Organic	786 lbs. Nit. Potash 585 lbs. Ammo. Sulph. 316 lbs. Superphos. 273 lbs. Bone meal	1
6% P_2O_5.....	3% Superphos. 3% Bone meal	40 lbs. filler	
5% K_2O.....	Nit. Potash		

8.

11% N......	5% Nit. Soda 5½% Ammo. Sulph. ½% Organic	645 lbs. Nit. Soda 537 lbs. Ammo. Sulph. 316 lbs. Superphos. 273 lbs. Bone meal	3
6% P_2O_5.....	3% Superphos. 3% Bone meal	200 lbs. Sulph. or Muriate Potash 29 lbs. filler	
5% K_2O.....	Sulph. or Muriate		

9.

9% N........	4% Ammo. Sulph. 4% Nit. Potash 1% Organic	571 lbs. Nit. Potash 390 lbs. Ammo. Sulph. 316 lbs. Superphos. 273 lbs. Bone meal	1

	6% P_2O_5.....	3% Superphos.	83 lbs. Sulph. Pot.	
		3% Bone meal	367 lbs. filler	
	6% K_2O......	Nitrate and Sulph.		
10.				
	10½% N.....	5% Nit. Soda	645 lbs. Nit. Soda	1
		5% Ammo. Sulph.	488 lbs. Ammo. Sulph.	
		½% Organic	83 lbs. Dried blood	
			579 lbs. Superphos.	
	6% P_2O_5.....	5½% Superphos.	120 lbs. Sulph. of Potash	
		½% Bone meal	46 lbs. Bone meal	
	3% K_2O.....	Sulphate	39 lbs. filler	
11.				
	9% N.......	2½% Nit. Potash or Soda	357 lbs. Nit. Potash	1
		6% Ammo. Sulph.	585 lbs. Ammo. Sulph.	
		½% Organic	474 lbs. Superphos.	
			409 lbs. Bone meal	
	9% P_2O_5.....	4½% Superphos.	140 lbs. Sulph. Potash	
		4½% Bone meal	35 lbs. filler	
	6% K_2O.....	Nitrate or Sulph.		
12.				
	9% N.......	2½% Ammo. Sulph.	244 lbs. Ammo. Sulph.	1
		6% Nit. Potash	857 lbs. Nit. Potash	
		½% Organic	526 lbs. Superphos.	
			273 lbs. Bone meal	
	8% P_2O_5.....	5% Superphos.	100 lbs. filler	
		3% Bone meal		
	6% K_2O.....	Nit. Potash		
13.				
	9% N.......	3% Nit. Soda	387 lbs. Nit. Soda	1
		3% Ammo. Sulph.	293 lbs. Ammo. Sulph.	
		3% Organic	333 lbs. Dried blood	
			636 lbs. Bone meal	
	7% P_2O_5.....	Bone meal	280 lbs. Sulphate Potash	
			71 lbs. filler	
	7% K_2O.....	Sulphate		
14.				
	8% N........	5.33% Ammo. Sulph.	522 lbs. Ammo. Sulph.	1
		2.67% Pot. Nit.	379 lbs. Pot. Nit.	
			739 lbs. Superphos.	
	7% P_2O_5.....	Superphos. ?	173 lbs. Sulph. Potash	
			146 lbs. filler	
	7% K_2O.....	Nit. and Sulph.		
15.				
	7% N........	2% Ammo. Sulph.	195 lbs. Ammo. Sulph.	2
		2% Nit. Potash	286 lbs. Pot. Nit.	
		3% Organic	417 lbs. Dried blood (?)	
			368 lbs. Superphos.	
	7% P_2O_5.....	3½% Superphos.	160 lbs. Sulph. or Muriate Potash	
		3½% Bone meal	318 lbs. Bone meal	
			256 lbs. filler	
	6% K_2O.....	2% Nit. Pot.		
		4% Sulph. Pot.		
16.				
	7% N.......	3¼% Nit. Soda	419 lbs. Nit. Soda	1
		3¼% Ammo. Sulph.	317 lbs. Ammo. Sulph.	
		½% Organic	789 lbs. Superphos.	
			227 lbs. Bone meal	

	10% P_2O_5....	7½% Superphos.	160 lbs. Sulph. or Muriate Potash	
		2½% Bone meal	88 lbs. filler	
	4% K_2O.....	Muriate or Sulph.		
17.				
	11¼% N....	5¾% Nit. Soda	742 lbs. Nit. Soda	1
		5% Ammo. Sulph.	488 lbs. Ammo. Sulph.	
		½% Organic	395 lbs. Superphos.	
			273 lbs. Bone meal	
	6¾% P_2O_5...	3¾% Superphos.	102 lbs. filler	
		3% Bone meal		
18.				
	8% N........	2⅔% Nit. Soda	342 lbs. Nit. Soda	1
		5⅓% Ammo. Sulph.	522 lbs. Ammo. Sulph.	
			632 lbs. Superphos.	
	7% P_2O_5.....	6% Water Soluble	91 lbs. Bone meal	
		1% Bone meal	413 lbs. filler	
19.				
	8% N.......	4% Nitrate	516 lbs. Nit. Soda	4
		4% Sulphate	390 lbs. Ammo. Sulph.	
			842 lbs. Superphos.	
	10% P_2O_5....	8% Water soluble	182 lbs. Bone meal	
		2% Bone meal	70 lbs. filler	

Formulas 1 to 4 inclusive are used in districts where tests have shown a potash shortage but practically no response to phosphoric acid.

We believe that these formulas serve the purpose very well. Nos. 1, 2 and 3 are very concentrated, carrying little filler. No. 4 is not quite so good, carrying as it does 370 pounds of filler or inert matter. For every ton of it used, freight must be paid on 370 pounds of useless material, as well as packing it up steep trails. We believe a saving on freight and handling could be made by adding 1 per cent to each ingredient, making the formula 12-4-8 and using, say, 10 to 15 per cent less of it.

Nos. 5, 6, 7, 8 and 13 are all very good for conditions where a general fertilizer is wanted, that is, where the need for neither phosphoric acid or potash predominates. We prefer 5, 6, 7 or 8 to 13. The 3 per cent organic nitrogen in 13 makes it more expensive, while our tests show organic nitrogen to be less efficient than the soluble forms.

No. 9 has entirely too much filler, 367 pounds. Either 5, 6, 7 or 8 could be substituted to advantage, the amounts applied being cut down to correspond to the increased nitrogen.

No. 10 is good where the soil shows some need for phosphoric acid while the potash requirements are not especially manifest.

Nos. 11 and 12 are good formulas. They are used on places where phosphoric acid especially, in addition to nitrogen, is wanted.

No. 14 has 146 pounds of filler; this is too much. The nitrogen could be increased with a corresponding decrease in the amount of fertilizer used.

No. 15. We believe better results could be obtained if this formula were changed for No. 5, for instance. Cane is a heavy nitrogen feeder and, for best results, we like to see nitrogen predominate in our mixtures, and 3 per cent organic nitrogen makes it more expensive.

No. 17 is a good mixture where potash is not wanted.

TABLE I

Plantation	Formula	Pounds of Mixed Fertilizer	Number of Applications	Second Season Material Used	Second Season Number of Applications	Total Pounds per Acre N	Total Pounds per Acre P_2O_5	Total Pounds per Acre K_2O
Waiakea Mill Co.	2	1250 to plant	Plant 2	N. of S.	1	150–210	23–53	75–175
		750 to 1750 to ratoons	Ratoons 1 or 2	320 to 500				
Olaa Sugar Co., Ltd.	3, 3A	1750 for 1st and 2nd season			4 altogether	193	0–53	158
Hilo Sugar Co.	1	500, M. F., 1000 P. N.	3	500 P. N.	1	210	25	150
Onomea Sugar Co.	1	1500 to 1800	3	500–600 P. N.	1	255–291	75–90	200–240
Pepeekeo Sugar Co.	1	500 to 1000 (?)	2	250–500 P. N.		....	.....	....
Honomu Sugar Co.	1	1125	2	425 P. N.	1	195	56	155
			Mauka lands 3					
Hakalau Plantation Co.	1	1200–1500	Plant 3	300–400 N. S.	1	190	60–75	120–150
			Ratoons 2					
Laupahoehoe Sugar Co.	8	1000–1200	3–4	375–625 N. S.	1–2	168–229	60–72	50–60
Kaiwiki Sugar Co., Ltd.	8	1250	2	250 N. S.	1	176	75	63
Hamakua Mill Co.	4	1000	2	250 N. S.	1	149	30	70
Paauhau Sugar Plantation Co.		250 bone meal,	2–4	300–600 N. S.	1–2	149–196	58	0–150
		600 N. of S.						
		0 to 150 lbs. K_2O from molasses ash						
Kaeleku Plantation Co., Ltd.	5	1000	1–2	300–600 N. S.		156–203	60	60
Niulii Mill & Plantation	5	1000	3	250–300 N. S.	1	150–156	60	60
Union Mill Company	7	500 to 750	1	250–500 N. S.	1	100–170	30	25
Kohala Sugar Company	13	1250	2	250–300 N. S.	1	152–160	88	88
Halawa Plantation, Ltd.	8	800–1000	2	250–300 N. S.	1	127–156	48–60	40–50
Hawi Mill & Plantation Co., Ltd.		1000–1250 lbs. N. of S.	N. of S. used throughout		2	155–194		
Hutchinson Sugar Plantation Co.	5	1000–1500	3	250 N. S.	1	150–204	60–90	60–90
Hawaiian Agricultural Co.	5	1200–1700	3	225–300	1	167–233	72–102	72–102
Maui Agricultural Co., Ltd.	19	625	1	550 N. S.	2	167	63	
				150 Am. Sulph.				
Olowalu Company	5	1000 plant and long rat.	2	400–650 N. S.	1	170–210	60	60
		750 short ratoon	1			143–183	45	45
Wailuku Sugar Co.	6	1000 plant	2	600 N. S. plant	1	204	60	60
		1000 ratoons	1	400 N. S. ratoon	1	173	60	60
		1000 N. S. short ratoon	1			156		
Hawaiian Commercial & Sug. Co.	19	625	1	750 N. S. ratoons	2–3	167	63	
		625	1	850 N. S. plant	2–3	182	63	
Pioneer Mill Co., Ltd.		437½ Superphos. upper lands	Plant 2					
		437½ Am. Sulph.	Ratoons 1	567½ N. S.	1	175	0–87	
Waianae Company		60 lbs. N. from N. of L.	3	90 lbs. N. from N. of L.	2	150		
Waimanalo Sugar Co.	6	875 plant and long ratoon	1	625 N. S.	1	194	53	53
		625 short rat. 250 lbs. N. S.	2			108	37	37
Kahuku Plantation Co.	19	750 plant	1	800–1000 N. S.	1	184–215	75	75
		750 long ratoon	1	600–1000 N. S.	1	153–215	75	75
		375 short rat. 300–400 lbs. N. S.	2			76–92	38	38
Ewa Plantation Co.		175–275 lbs. N.	1–2	75–150 N. *	1–2	175–275	0–200	
Honolulu Plantation Co.	15	900–1000	2	625 N. of S.	1	160–167	63–70	54–60
Oahu Sugar Co., Ltd.	11	1000	1	625–875 N. of S.	2	187–225	90	60
Waialua Agricultural Co., Ltd.	14	1000	1	500–600 N. S.	1	158–173	70	70
Kekaha Sugar Co., Ltd.	16	750–1000	1	800–1000 N. S.	3	196–244	75–100	30–40
		125 N. S.						
The Waimea Sugar Mill Co.	16	1000	1	1000 N. S.	3–4	225	100	40
Hawaiian Sugar Co.	18	1000	1–2	300–400 N. S.	1–4	126–142	70	
The Koloa Sugar Co.	12	1000	1	250–1000 N. S.	1–2	129–245	80	60
The Lihue Plantation Co., Ltd.	17	600–1000 plant in makai fields				192–236	41–67	
			1	800 N. S. makai	2	107–162	27–41	
		400–600 plant in mauka fields		400–600 N. S. mauka				
		400–600 long and short ratoon						
McBryde Sugar Co., Ltd.	19	625	1	250 lbs. mixture (½ Nit., ½ Sul.)	2	150–225	63	
				500–700 lbs. Nit. Soda				
Kilauea Sugar Plantation Co.	5	800	Plant 1					
			Ratoons 2	375–500 Nit. Soda or Nit. L.	1	146–164	48	48

No. 18 carried 413 pounds of filler, which is a waste. We would favor increasing the nitrogen and adding some potash to this.

Nos. 16 and 19. At first sight, we do not like these mixtures. We know of no reason, and have access to no data in the Islands which indicate that phosphoric acid should predominate in a mixed fertilizer. Sugar cane uses less phosphoric acid than it does of either nitrogen or potash. A ton of cane uses approximately 3 to 4 pounds of nitrogen, 1.5 pounds of phosphoric acid and 2.7 pounds of potash. Our soils, except for some upper areas, are fairly well supplied with phosphoric aid. But when one inquires as to how these mixtures are used the objection to them tends to largely disappear. This mixture is used for the first application only and the phosphoric acid is made high in order that all of it may be applied in one dose to the young cane. This is the correct procedure because the main function of phosphoric acid is to promote root growth, so the only final objection that we have to this mixture is that it contains no potash.

Summary

First: For districts of potash shortage and no special need for phosphoric acid we believe formulas 1 and 2 to be the best.

Second: For districts where phosphoric acid is lacking and the need for potash not so great we suggest No. 11.

Third: For general conditions where neither phosphoric acid or potash are particularly lacking, Nos. 5, 6, 7 or 8 serve the purpose very well. They are practically identical. It will be noted that these formulas are all for concentrated mixtures. This saves bags, freight and handling. In order to put up these mixtures the use of potash nitrate is sometimes necessary. If for any reason potash nitrate becomes unavailable these formulas will need to be changed.

Total Amounts of Fertilizer Used

We tabulate herewith, in Table I, the total amounts of both mixed fertilizer and nitrogen dressing used by the different plantations; also number of doses in which it is applied and the total nitrogen, phosphoric acid and potash which this involves.

A study of this list shows that nitrogen is used in amounts ranging from about 100 pounds to approximately 300 pounds per acre. These extremes are not abnormal. Fields producing 90 to 100 or more tons of cane per acre need 300 or more pounds of nitrogen if they are to keep their fertility. On the other hand, some other field which, on account of altitude, lack of water, disease, or unsuited variety, produces but 30 tons, does not need more than 100 pounds of nitrogen per acre. The point here is that if some other factor is keeping down the yield to a certain level, increasing the fertilizer used will not raise the yield above this level, until the disturbing factor is eliminated.

We note that quite a large number of the managers report a uniform application of fertilizer to all fields. We believe this to be wrong. Fertilizing cannot be made into a standard routine if the best results are to be obtained. No plantation has uniform fields or uniform conditions, and in order to obtain the best results each field should be studied by itself and fertilizer used accordingly.

This point is well stated in the reply of one plantation to question 3: "Please state briefly your policy in regard to the amounts used in various fields." We have heard a great deal recently about the enormous yields obtained at Ewa. Here is their answer to question 3: "No set rule; varies with (a) time of starting field, (b) time of harvesting, (c) soil conditions, (d) stand of cane, (e) drainage conditions, (f) weed condition of field."

We strongly urge upon all those having to do with the fertilization of our sugar cane to carefully consider these points.

We note that most of our fertilizer is applied in from 2 to 3 doses, sometimes 4, depending on the length of crop. We do not believe it is necessary to apply fertilizer in more than 4 doses; on the other hand, unless the crop is to be only 12 months or so, it may not be wise to have less than 2 doses.

Age of Cane When Fertilized—Practice in Regard to Weeds

We give herewith, in Table II, a list of the plantations showing at what age the first dose of fertilizer is applied, how long before harvest is the last fertilization on and what the practice is in regard to weeding before fertilization.

The list is self-explanatory and requires no extended comment. The first fertilizer is applied when the cane is from about one to six months old, and the last applied six to eighteen months before harvest.

We believe everyone realizes the importance of an early start of the young cane and that the apparent delay in fertilization in some cases is due to unavoidable circumstances. For instance, there is no use to fertilize a field unless you have labor to irrigate and weed it as well. In other words, the practice may be one of compulsion and not choice. But every effort should be made not to unduly delay fertilizing the young cane. Early fertilization not only gives one more growing time, but by hastening the closing in of the cane weeds are suppressed, which, in turn, helps in the control of mosaic.

The opinion is general that fields should be clean when fertilized. But the "intensity" of the opinion varies to some extent. Some managers say they do not fertilize until the fields are clean, no matter how much that delays fertilization. Others prefer to go ahead with the fertilizer rather than be unduly delayed. That is a question for serious consideration. Both sides have good arguments. However, we are inclined to take the middle of the road in this as being probably better than either extreme. Of course, we all know that fertilizer should be applied to clean fields and that we should exert every effort to do so. But, sometimes after "exerting every effort" the fields are still not clean, then what are you going to do? Let it go without fertilizer, or, if the cane is big enough, give a big application of fertilizer to force the cane above the weeds?

Winter Fertilization

Opinion in regard to winter fertilization is fairly well divided, twenty-one managers report in favor and seventeen against.

Mr. Larsen, of Kilauea, says: "No. It is very dangerous with us, since we get no response in a cold and wet winter."

TABLE II

Plantation	Age of Cane at First Fertilization	Do You Weed Before Fertilizing?	How Long Before Harvest is Last Fertilization?
Hilo Sugar Company	2 to 4 months	Must be clean	Not less than 12 months
Onomea Sugar Company	1 foot high; 2nd, 3 months later	Yes—or immediately after	10 to 12 months or more
Pepeekeo Sugar Company	No fixed rule	Yes—or immediately after	12 months
Honomu Sugar Company	After first hoeing	Always weed	8 to 10 months
Hakalau Plantation Company	After first hoeing	Clean if possible without too much delay	Finish by May
Laupahoehoe Sugar Co	4 to 6 weeks	Weed before fertilizing	5 to 6 months
Kaiwiki Sugar Co., Ltd	4 months	Weed before fertilizing	12 months
Hamakua Mill Company	2 months	Weed before fertilizing	12 months
Paauhau Sugar Plantation Co	1 month	Weed before fertilizing	12 months
Niulii Mill & Plantation	2 months	Weed first	10 to 12 months
Halawa Plantation, Ltd	3 months	Weed first	12 months
Kohala Sugar Co	3 months	Weed if necessary	Not less than 10 months
Union Mill Co	4 to 6 months	Weed first	At least one year
Hawi Mill & Plantation Co., Ltd			Not less than 10 months
Hutchinson Sugar Plantation Co	Right after offbarring	Weed first	12 months or more
Hawaiian Agricultural Co	Get all fertilizer on before cane is 12 months	Weed first	12 months or more
Olaa Sugar Co., Ltd	3-6-9-14 months	Yes—in times of labor shortage not so careful	9 months
Waiakea Mill Company	2-5 months	Always weed	9 months to one year
Pioneer Mill Co., Ltd	1½ to 2 feet high or sooner	Weed if possible	One year
Olowalu Company	1 to 2 months	Weed first	10 to 12 months
Wailuku Sugar Co	1 to 2 months	Weed first	12 to 18 months
Hawaiian Commercial & Sugar Co	4 to 5 months	Weed first	Last application in March
Maui Agricultural Co., Ltd	3 to 6 months	Generally, clean fields	9 to 12 months
Kaeleku Plantation Co., Ltd	3 to 4 months	Always weed first	8 months
Waimanalo Sugar Co	When about 1½ feet high	Weed first	At least one year
Kahuku Plantation Co	8 to 12 weeks	Weed first	Finish by June 1
Waialua Agricultural Co., Ltd	4 to 5 months	Weed first	10 to 12 months
Waianae Company	Plant 5th water, ratoon 1 or 2 water	Weed when possible	8 to 12 months
Ewa Plantation Company	Varies—no set rule	Always clean fields	Not less than 12 months
Oahu Sugar Co., Ltd	1½ to 2 months	Clean when possible	8 to 12 months
Honolulu Plantation Co	2 months	Always clean fields	9 to 18 months
Kekaha Sugar Co., Ltd	2 months	Weed first	6 months
Waimea Sugar Mill Co	1 month	Weed if possible	10 months
Hawaiian Sugar Co	3 months	Fields must be clean first	5 to 6 months
McBryde Sugar Co., Ltd	1 to 3 months	Weed if possible	10 to 12 months
Koloa Sugar Co	1½ to 2 months	Weed if possible	12 months or more
Lihue Plantation Co., Ltd	3 to 4 months	Clean	Finish by June 15
Kilauea Sugar Plantation Co	3 to 6 months	Weed first or immediately after	Not less than 9 months

Mr. Baldwin, at Kahuku, takes the other side, saying: "Yes, very beneficial at Kahuku, as it appears to assist cane to withstand the wet, cold climatic conditions of this side of the island."

Mr. Thomson, at Waialua, sees no merit in it. "I am opposed to winter fertilization, as it has a tendency to make the cane very soft and more susceptible to disease."

Mr. Penhallow, at Wailuku, explains his position as follows: "Yes, good practice for Wailuku. All fertilizer is applied before end of January, usually in December in order to get benefit of winter rains. Have better growth on cane since this has been made standard practice here."

The same argument applies in Kohala and Hamakua when the rains come in winter and the summers are generally dry.

Mud Press Cake

Only one or two plantations report not using all their mud press cake on the fields. The majority of opinion is that the best way to use it is by plowing in plant fields. "Dressing up" poor spots is a close second. It is generally applied fresh, although in many places, on account of the rush of harvesting it is piled up to the end of the season. The majority of opinions also agree that it should be covered, but this is not always done. Much of the press cake is applied in the irrigation water. When used this way much of the nitrogen and organic matter is lost, while the phosphoric acid, potash and lime are delayed in their action as they cannot become active until after they become incorporated in the soil.

The opinion of the value of a ton of press cake varies rather widely. Values ranging from $2 to $20 per ton are given; $5 to $10 is the figure most commonly given, followed rather closely by a value of from $2 to $5. As a whole the managers along the Hilo coast give press cake a higher value than do the managers from other districts.

One manager (not from the Hilo coast) said he had "No press cake, thank God!" so that is another value. But this manager was thinking of the mill rather than the field.

Liming

But six plantations report the use of any lime on their fields, and most of these report its use occasionally and not as a regular practice. When used it is applied at the rate of from one to four tons per acre.

The Need of Some Filler in Mixed Fertilizer Explained by the Manufacturer

In the mixing of fertilizer of a certain guarantee it is not possible, of course, to get this exactly in a commercial plant for a number of reasons, such as slight variations in the composition of the materials used, the difficulty of taking samples which absolutely represent the lot sampled, the allowable errors in analyses, etc. So, in order to be on the safe side and not have to pay a shortage rebate the manufacturer generally makes his mixture slightly above guarantee. In

order to do this, certain allowance must be made for some filler. Mixtures showing 25 to 50 pounds of filler may in reality not contain filler at all, but be made up by using slightly more of the different fertilizer materials called for. So, practically 25 or 50 pounds of filler should be disregarded. But amounts above, say 60 pounds, are not necessary.

In order to bring out this point we have asked C. G. Owen, Honolulu manager of the Pacific Guano & Fertilizer Company, to briefly outline the mixing of concentrated goods from the manufacturers' point of view.

Mr. Owen submitted his views as follows:

The manufacturer recognizes without question the advantage of using highest concentrated mixed fertilizers where unit values of nitrogen, phosphoric acid and potash are constant, because the cost of application becomes less by reason of less labor, less freight and less bags per unit of plant food applied. In compounding a ton of commercial high grade fertilizer it is not practical to figure closer than 97 per cent of ingredients, thus allowing 3 per cent for nitrogen, phosphoric acid and potash content in excess of the guarantee. We believe the reason for this is quite clear, but as an example we will say that if a formula is called for as follows:

12% Nitrogen—6% sulphate
5% nitrate
1% organic
6% Phosphoric Acid—3% bonemeal
3% superphosphate
6% Potash—from sulphate, muriate or nitrate

the manufacturer could not take the risk of using only sufficient materials equal to exactly the guarantee, because it would be practically impossible to draw samples of this mixture which would analyze up to the guarantee of each ingredient. The materials themselves from which such a fertilizer would be composed have different specific gravities, and when mixed together even with the greatest care will not retain their relative position within the mass, but tend to separate according to their different specific gravities; the heavier materials gradually shifting from position in the handling of the goods from the upper part of the bag in which they are transported and the lighter materials coming to the top. Even should their position remain undisturbed, the ordinary commercial laboratory control and analyses are not sufficiently accurate to secure positive results within one- or two-tenths of a per cent. Therefore, should the manufacturer figure to fill the guarantee exactly the chemical analysis would show a certain range, one element higher than guaranteed while other elements would be below the guarantee, and should it just so happen that the averages were in phosphoric acid and potash, the less valuable plant foods, and the shortage be in nitrogen, the manufacturer would be subject to a continuous lot of claims for shortages which did not actually exist. Thus it is evident, we think, that no commercial fertilizer could be figured closer than 97 per cent or 1940 pounds to the ton.

In regard to certain of the formulas reported, which show fillers of from 200 to 400 pounds, by a strict calculation rather than by practice, these additions to the make-up do not always exist except by the nature of the raw materials used, because phosphatic materials and organic nitrogen materials are far from standard, and there is sufficient range in the analyses of these raw materials to take care of the so-called filler to a large degree, for commercial bonemeal comes to the manufacturer ranging in analyses from 21 per cent phosphoric acid to 31 per cent phosphoric acid, superphosphate from 16 per cent to 20 per cent; dried blood and tankage also have great variations, consequently manufacturers in filling what might be termed a lower grade formula than the usual high grade make use of the lower grade material thus obviating the necessity of adding much filler.

The fertilizer manufacturer would welcome an adoption of the general principle of the consumer using highly concentrated mixed fertilizers because the maximum good could be obtained from the least tonnage and a fertilizer plant could be established to handle the least number of tons to get the greatest benefit.

As newer and higher concentrated raw materials are produced at prices equal to present cost of materials which are now available in the market and in regular supply, the concentration of fertilizezrs can be raised. For instance, when ammonium nitrate and ammonium phosphate, urea and potassium nitrate can be produced as cheaply as present materials are produced, then higher concentrated goods can come into general use. At the present time these materials are limited in quantity and the cost is generally so high that the use of them offsets the savings in freight, labor and bags as first mentioned.

We would say that at the present time commercial fertilizer calculated to within 90 per cent of the possible concentration would be economically sound, for we will assume that freight, bags and handling have a combined average value of $10 per ton, 3 per cent of this value would have to be allowed for a laboratory analyses margin, as previously explained, leaving 7 per cent or the equivalent to 70 cents per ton, which might be saved by the elimination of all fillers.

In calculating the formulae given under mixed fertilizers at the beginning of this article, the following analyses were used:

Ammonium sulphate	20.5% N	....
Nitrate of soda	15.5% N	....
Nitrate of potash	14.0% N	14% K_2O
Bone meal	3.5% N	22% P_2O_5
Superphosphate		19% P_2O_5
Sulphate or muriate of potash		50% K_2O
Dried blood	13.0% N	....

In order to make this report complete, some of the details of the fertilizer practices on the various plantations are given herewith:

1. What is the total amount per acre used? If you use different quantities on plant and ratoons (long and short) on mauka and makai or good and poor fields, please give the various amounts. Please state briefly your policy in regard to the amounts used in various fields.

Olaa Sugar Company, Ltd.: We use 1,750 pounds per acre. We make no difference. All fields get the same amount.

Waiakea Mill Company: Standard application is 1,250 pounds per acre. All plant cane receives this amount. On ratoons, the amount is varied from 750 pounds per acre to 1,750 pounds per acre, depending on the condition of the stools. It is our policy to give heavier applications to better cane and lighter applications to poorer fields.

Hilo Sugar Company: We use 500 pounds B-1 per acre throughout the entire area.

Application Plan—Hilo Sugar Co.

Ratoon

Application	Lbs. Fertilizer	Lbs. Nitrogen	Lbs. Potash	Lbs. Phos. Acid
1st	125 P–N	18¾	12½	....
2nd	500 B–1	60	50	25
3rd	375 P N	56¼	37½	....
Spring	500 P N	75	50	....
Total	1500	210	150	25

Plant

1st	250 B-1	30	25	12½
2nd	250 B-1	30	25	12½
3rd	500 P N	75	50	....
Spring	500 P N	75	50	....
Total.	1500	210	150	25

Onomea Sugar Company: We use 1,500 to 1,800 pounds per acre per crop. All pretty much alike, but somewhat heavier on the knolls than the hollows.

Pepeekeo Sugar Company: Different quantities are used according to condition of growth. The poorer upper lands receive 1 to 2 bags per acre. More than good lands as a rule.

Honomu Sugar Company: We use 1,125 pounds—the same amount for both plant and ratoons.

On the mauka fields fertilization is not as heavy if the crop does not warrant it.

Hakalau Plantation Company: We use from 1,200 to 1,500 pounds per acre, this amount applies to both mauka and makai lands.

I don't think it good practice to cut down on the amount applied to your good fields, and increasing the amount on poor soil.

By applying a good amount of fertilizer to your good soil, the fertilizer has something to work on, and your returns are very much increased. Whereas increasing the amount on poor light soil, you stand a chance of losing a lot of it, by being washed away by rain, and it is completely lost.

Laupahoehoe Sugar Company: 1,000 to 1,200 pounds high grade; 500 to 700 pounds nitrate. Applications depending on conditions.

Kaiwiki Sugar Company, Ltd.: We use 1,250 pounds.

Hamakua Mill Company: We use 1,000 pounds.

Paauhau Sugar Plantation Company: From 800 to 1,200 pounds nitrate of soda, 15.5 per cent N. From 0 to 250 pounds bonemeal, 22 per cent P. From 0 to 150 pounds potash from molasses, 25 per cent K.

Amounts applied to various mauka or makai fields depend upon the general appearance and stand of cane, drought conditions that may affect second season fertilization, and the fertility of the field in general as judged by previous crop yields.

Niulii Mill and Plantation: 1,000 pounds high grade, 250 to 300 pounds nitrate.

Halawa Plantation, Ltd.: From 800 to 1,000 pounds per acre, according to location and stand of cane. On short ratoons, we sometimes use 300 pounds sulphate of ammonia and 600 pounds nitrate of soda, applied in three doses, by hand.

Kohala Sugar Company: We use 1,250 pounds. Ratoons and plant treated alike.

Union Mill Company: Five hundred pounds applied per acre in one dose, as a rule. This may be increased to 750 pounds per acre on the better fields.

Hawaiian Agricultural Company: From 1,200 pounds to 1,700 pounds. No difference made with plant or ratoon, nor yet mauka or makai. We, however, make a difference with some of our fields, depending upon the natural fertility. These we are generous with, but as a rule curtail our amounts upon fields where moisture is uncertain.

Hutchinson Sugar Plantation Company: The amount varies according to the fields. We apply more on our good fields than we do on our poorer fields and 1,000 pounds to 1,500 pounds per acre is applied.

Kaeleku Sugar Company: One thousand pounds per acre is our standard application.

Healthy ratoons all in one dose. Backward and dried fields two doses of 500 pounds each. Plant cane 400 and 600 pounds in two applications.

Maui Agricultural Company, Ltd.: All fields get 625 pounds per acre.

Hawaiian Commercial and Sugar Company: We use 625 pounds per acre on both plant and ratoons. All fields fertilized the same.

Wailuku Sugar Company: Plant cane, 1,000 pounds in two applications. Ratoons, 1,000 pounds in one application. Short ratoons, none.

This practice determined from results of fertilizer experiments carried on in various parts of the plantation.

Olowalu Company: We use 1,000 pounds per acre on plant and long ratoons, and 750 pounds per acre on short ratoons.

Pioneer Mill Company, Ltd.: Last year we used sulphate of ammonia for first season with superphosphate also applied on our mauka fields, the lower fields getting nitrogen only. Both plant and ratoons are given equal amounts, 3½ bags or 437½ pounds of sulphate and 4½ bags or 567½ pounds of nitrate. This gives a total of 175 pounds of nitrogen. Mauka fields get in addition 3½ bags or 437½ pounds of superphosphate or 87½ pounds of P_2O_5.

Waianae Company: Total amount 150 pounds of nitrogen.

Ewa Plantation Company: No set rule; varies with

(a) Time of starting field;
(b) Time of harvesting field;
(c) Soil conditions;
(d) Stand of cane;
(e) Drainage conditions;
(f) Weed condition of field.

Total amounts vary from 175 to 275 pounds nitrogen.

Oahu Sugar Company, Ltd.: We use an average of 1,000 pounds an acre.

Honolulu Plantation Company: We use from 900 pounds to 1,000 pounds per acre on all cane.

Waimanalo Sugar Company: We use 875 pounds on plant and long ratoons. Short ratoons, we apply 250 pounds of nitrate of soda about 3 weeks after harvesting and follow with 625 pounds of high grade about 2 months later.

Kahuku Plantation Company: Long ratoons, 5 bags, 750 pounds. Plant, 5 bags, 750 pounds. Short ratoons, 3 bags, 375 pounds.

We make no deviation from the above figures on account of soil or crop differences.

Waialua Agricultural Company, Ltd.: We use the same amount on all fields—1,000 pounds high grade, 500 to 600 pounds nitrate of soda. I do not believe in adding more to the poor spots. Land that is considered poor should, if possible, be discarded or left fallow for a crop or two.

Kekaha Sugar Company: We use from 750 to 1,000 pounds per acre. All ratoon fields get a dose of 125 pounds of nitrate of soda per acre when, or shortly after, cane is cut; when 2 months old we apply high grade and after that we give 800 pounds of nitrate of lime or soda in 2 or 3 applications.

Waimea Sugar Mill Company: We use 1,000 pounds per acre on all fields.

Hawaiian Sugar Company: We use 1,000 pounds per acre on both plant and ratoons, and extra doses where cane is poor.

McBryde Sugar Plantation Company: We use 625 pounds mixed fertilizer per acre. Total nitrogen for crop received in fields varies from 150 to 225 pounds per acre. This depends on stand, soil, location, variety and the controlling factor here, viz: water. Good fields get more, poor fields less.

Koloa Sugar Company: Amount has been increased the last two years. Last year we applied 875 pounds per acre, this year we increased it to 1,000 pounds per acre. This is now applied regularly to all fields, the total nitrogen being varied according to field locations and soil types when second season applications are made. Mauka, unirrigated areas get less than more fertile irrigated areas. We try to govern our fertilization by results of experiments in typical soil types of the various sections. As available data is as yet meagre we are more or less playing safe with kind and amount of fertilizer. Mauka areas get 100 to 130 pounds nitrate per acre, makai areas 150 to 225 pounds per acre nitrate, and plant and ratoon fields with a strong stand get heavy doses; poorer cane lighter doses.

Lihue Plantation Company, Ltd.:

From 600 to 1,000 pounds for plant in our makai fields;
From 400 to 600 pounds for plant in our mauka fields;
From 400 to 600 pounds for long and short ratoons.

The amount varies according to the variety of cane and location of fields.

Kilauea Sugar Plantation Company: In good fields, about 800 pounds per acre. In poor fields less. This depends so much on condition of cane and time of year. If we have a good stand, free of weeds early in the summer we apply one big dose. If it is late in the fall when the cane is ready we wait until spring. In thin soils we apply less, in deeper soils more.

2. In how many doses is this fertilizer applied?

Olaa Sugar Company, Ltd.: 3-4-2 5 bags. The 2 bags dressing comes in the winter months.

Waiakea Mill Company: On plant cane two applications—1st 500 pounds, 2nd 750. On good ratoons one application of 1,250 pounds or one of 1,000 to 1,250 pounds, and the second of 500 pounds. On poor ratoons two applications—1st 500 per acre.

Hilo Sugar Company: One application on ratoons. Two applications on plant.

Onomea Sugar Company: Three; two in the first growing season and one in second. There are times when we apply three times the first season, depending on climatic conditions and if we get the fertilizer early in the season.

Pepeekeo Sugar Company: Generally in two applications.

Honomu Sugar Company: Two doses—above 1,200 feet elevation, three applications.

Hakalau Plantation Compny: Three doses on plant and two on ratoon.

Laupahoehoe Sugar Company: Three and four.

Kaiwiki Sugar Company, Ltd.: Two.

Hamakua Mill Company: Two.

Paauhau Sugar Plantation Company: From 2 to 4.

Niulii Mill and Plantation: Usually 3 applications.

Halawa Plantation, Ltd.: High grade in 2 doses.

Kohala Sugar Company: Two applications.

Union Mill Company: One.

Hawi Mill and Plantation Co., Ltd.: ....

Hawaiian Agricultural Company: Three.

Hutchinson Sugar Plantation Company: As a rule, 3 times.

Kaeleku Sugar Company: One and two, depending on the vigor of the crop.

Maui Agricultural Company, Ltd.: One.

Hawaiian Commercial and Sugar Company: One dose.

Wailuku Sugar Company: Plant cane 2 equal doses (500 pounds even), long ratoons 1 dose (1,000 pounds).

Olowalu Company: On plant and long ratoons 2 doses, on short ratoons 1 dose.

Pioneer Mill Company, Ltd.: Plant cane first season fertilizer applied in 2 doses, second season 1. Ratoon cane first season fertilizer applied in 1 dose and second season in 1 dose.

Waianae Company: Three.

Ewa Plantation Company: No set rule; varies as in Question 3. Not less than 2 doses, not more than 4.

Oahu Sugar Company, Ltd.: One dose for high grade.

Honolulu Plantation Company: Two doses.

Waimanalo Sugar Company: One.

Kahuku Plantation Company: One application.

Waialua Agricultural Company, Ltd.: One dose for high grade and one dose for nitrate.

Kekaha Sugar Company, Ltd.: One dose.

Waimea Sugar Mill Company: One.

Hawaiian Sugar Company: Very young cane 2 doses. Cane 4 months old, one dose.

McBryde Sugar Plantation Company: One.

Koloa Sugar Company: In most cases of late we put on 1,000 pounds in one dose and find results warrant it.

Lihue Plantation Company, Ltd.: One.

Kilauea Sugar Plantation Company: One dose on plant. Usually 2 doses on ratoons.

3. Do you always make it a policy to weed your fields before applying the fertilizer, or when the proper time comes do you fertilize, regardless of the condition of the field, rather than unduly delay this application?

Olaa Sugar Company, Ltd.: Yes, although when there is an acute shortage of labor, as in 1921, we are not very particular.

Waiakea Mill Company: We always weed our fields before applying fertilizer, even if this causes some delay in time of application.

Hilo Sugar Company: We always weed our fields before fertilizing.

Onomea Sugar Company: We never apply fertilizer to weedy fields unless it is the intention to cover everything up immediately, such as hilling up.

Pepeekeo Sugar Company: Where possible, but have found good results from applying a week ahead of hoeing as the cane gets hold of the fertilizer and makes a rapid growth and gets well ahead of the grass after hoeing, thus widening the period between hoeings.

Honomu Sugar Company: We always weed the fields previous to applying fertilizer.

Hakalau Plantation Company: We always endeavor to clean our fields before applying fertilizer but do not believe in delaying the application.

Laupahoehoe Sugar Company: We weed before applying fertilizer.

Kaiwiki Sugar Company, Ltd.: Always clear fields before fertilizing.

Hamakua Mill Company: When clean.

Paauhau Sugar Plantation Company: We do not fertilize unless field has been weeded, and like to see our way of keeping field clear after fertilizing. Do not believe in applying fertilizer unless cane is reasonably free from weeds and pretty well closed between rows for second season fertilization.

Niulii Mill and Plantation: We make it a policy to weed the fields first.

Halawa Plantation, Ltd.: We always weed before applying fertilizer.

Kohala Sugar Company: If necessary, we always hoe our weeds before applying fertilizer.

Union Mill Company: Fertilizer is applied to clean fields only.

Hawaiian Agricultural Company: Never apply fertilizer unless fields are clean.

Hutchinson Sugar Plantation Company: We always weed our fields before fertilizing.

Kaeleku Sugar Company: Weed the fields. We would not apply otherwise regardless of how late the application.

Maui Agricultural Company, Ltd.: As a general rule fertilizers are not applied when the fields are in a weedy condition.

Hawaiian Commercial and Sugar Company: We weed and have the fields clean before fertilizing.

Wailuku Sugar Company: Fields are clean before fertilizer is applied.

Olowalu Company: Yes, always weed before fertilizing.

Pioneer Mill Company, Ltd.: We weed our fields before applying fertilizer, if possible.

Waianae Company: Weed whenever possible.

Ewa Plantation Company: Never apply fertilizer except in a clean field.

Oahu Sugar Company, Ltd.: Have fields clean whenever possible.

Honolulu Plantation Company: Always weed the fields first.

Waimanalo Sugar Company: Weed before applying fertilizer.

Kahuku Plantation Company: Always weed the fields and make an extra thorough weeding of reservoir and supply ditches.

Waialua Agricultural Company, Ltd.: We make it a point to have our fields clean and in good condition before applying fertilizer.

Kekaha Sugar Company, Ltd.: As a rule we weed before we fertilize. We would rather delay application than fertilize in dirty fields.

Waimea Sugar Mill Company: Applied on clean fields when possible.

Hawaiian Sugar Company: It is very important to have fields of sugar cane clean and free of weeds before fertilization and we make this a practice.

McBryde Sugar Company, Ltd.: Try to get fields weeded. Personal belief is to get fertilizer on even though field is weedy, if proper moisture assured, and if labor is such that weeds can be gotten soon. If rains come all plantation fields cannot get application at once.

Koloa Sugar Company: Where weeds are not heavy we often apply the fertilizer when cane is well up and able to keep ahead of grass. Labor permitting, we try to have weeding sufficiently advanced so as not to delay the fertilizer application. Whenever we can we weed ahead of the fertilizer application.

Kilauea Sugar Plantation Company: We weed first or sometimes apply the fertilizer directly ahead of the weeding.

Lihue Plantation Company, Ltd.: We prefer to have our fields clean.

4. How long before harvesting a field do you apply the last fertilizer?

Olaa Sugar Company, Ltd.: About 9 months.

Waiakea Mill Company: We apply nitrate as long as possible before harvesting. It usually runs from 9 months to a year ahead.

Hilo Sugar Company: As early as the size of cane will permit, but never later than a year before harvesting.

Onomea Sugar Company: Ten to 12 months or more. We aim to be through with our second year fertilization by the beginning or the end of May.

Pepeekeo Sugar Company: Twelve months if possible.

Honomu Sugar Company: From 8 to 10 months.

Hakalau Plantation Company: We endeavor not to fertilize after May, all our spring dressing is done between February and May.

Laupahoehoe Sugar Company: Five or 6 months.

Kaiwiki Sugar Company, Ltd.: One year.

Hamakua Mill Company: One year.

Paauhau Sugar Plantation Company: About 12 months.

Niulii Mill and Plantation: Ten to 12 months.

Halawa Plantation, Ltd.: About a year.

Kohala Sugar Company: At least 10 months before cutting.

Union Mill Company: At least a year.

Hawi Mill and Plantation Company, Ltd.: Our aim is not later than 10 months.

Hawaiian Agricultural Company: About a year; sometimes, owing to inability to harvest, 18 months.

Hutchinson Sugar Plantation Company: At least a year and often more.

Kaeleku Sugar Company: Eight months.

Maui Agricultural Company, Ltd.: Usually 9 to 12 months.

Hawaiian Commercial and Sugar Company: For the 1925 crop we finished applying nitrate of soda in March.

Wailuku Sugar Company: At least 12 months. Runs from 12 to 18 months.

Olowalu Company: Ten to 12 months.

Pioneer Mill Company, Ltd.: One year if possible.

Waianae Company: Long ratoons in June, short ratoons in January.

Ewa Plantation Company: Try to apply it at least 12 months before harvesting, but in December and January harvested fields the interval is 10 months.

Oahu Sugar Company, Ltd.: Eight to 12 months.

Honolulu Plantation Company: Nine to 18 months.

Waimanalo Sugar Company: At least a year.

Kahuku Plantation Company: June is the last date of general application. Harvest commences in December of the same year.

Waialua Agricultural Company, Ltd.: Five or 6 months (?), 10 to 12 months.

Kekaha Sugar Company, Ltd.: As a rule 6 months, sometimes less on short ratoons.

Waimea Sugar Mill Company: About 10 months.

Hawaiian Sugar Company: From 5 to 6 months.

McBryde Sugar Plantation Company: From 10 to 12 months.

Koloa Sugar Company: We try to make it as near a year as possible.

Kilauea Sugar Plantation Company: Not less than 9 months.

Lihue Plantation Company, Ltd.: We aim to have all our fertilizer in before June 15.

5. Do you practice so-called winter fertilization? What is your opinion in regard to this?

Olaa Sugar Company, Ltd.: Sometimes we apply a 2-bag dressing to some of our fields. We believe it keeps the plant growing and increases its root system, thereby putting it into a condition to readily absorb the spring dressing.

Waiakea Mill Company: No.

Hilo Sugar Company: Yes, we fertilize throughout the year. It is true that cane grows very slowly during the winter months, but if we do not apply fertilizer in the required amounts and at the proper time, the cane becomes very yellow and shows the need of same in winter as well as in summer.

Onomea Sugar Company: The only time we do this is when we are not able to get our regular work done sooner, not from choice. We believe it would be bad practice in this wet district.

Pepeekeo Sugar Company: Prefer to have some warmth and bacterial action in the soil before applying. Generally start second season's fertilization about March.

Honomu Sugar Company: Just as little as possible. In my opinion it is not good practice to fertilize during the winter months. The cane can make but little use of the fertilizer and there is more or less loss of nitrogen on account of the heavy rains of the winter season.

Hakalau Plantation Company: Most of our final or third application of fertilizer is done in winter months.

Laupahoehoe Sugar Company: We fertilize at any or all times when we consider necessary.

Kaiwiki Sugar Company, Ltd.: No.

Hamakua Mill Company: Sometimes; this depends on the season.

Paauhau Sugar Plantation Company: We believe that temperature is the limiting factor for cane growth during winter months. Lower fields, however, can be pushed ahead, if late, by fertilization every two months, if necessary.

Niulii Mill and Plantation: We prefer applying during summer months, but in the Kohala district on unirrigated fields it is usually too dry during those months, so we apply as soon as rain comes.

Halawa Plantation, Ltd.: ....

Kohala Sugar Company: We aim to have all fertilizing done by the middle of February.

Union Mill Company: No.

Hawi Mill and Plantation Company, Ltd.: No.

Hawaiian Agricultural Company: We apply so-called "spring dressing" at all times of the year. We do not believe in winter applications if it can be avoided.

Hutchinson Sugar Plantation Company: We fertilize at all times of the year. This is necessary under our conditions, where we harvest all the year.

Kaeleku Sugar Company: We do not approve of winter fertilization, and consider it more advantageous to defer fertilizing until spring.

Maui Agricultural Company, Ltd.: No.

Hawaiian Commercial and Sugar Company: ....

Wailuku Sugar Company: Yes, it is good practice for Wailuku. All fertilizer is applied before end of January—usually by December in order to get benefit of winter rains. Cane is usually closed in by this time and growth is stimulated by the fertilizer. Have better growth on cane since this has been made standard practice here.

Olowalu Company: We apply nitrate of soda on plant and long ratoons from early in January into March.

Pioneer Mill Company, Ltd.: We apply our spring dressing beginning in December and are through in March, most of the fertilizer going on in January and February. This gives us very good results.

Waianae Company: Yes. We have good results from winter fertilization.

Ewa Plantation Company: On early started cane, will apply a small October dose and get results which are profitable, as shown by experiments.

Oahu Sugar Company, Ltd.: No.

Honolulu Plantation Company: Have not tried it.

Waimanalo Sugar Company: No.

Kahuku Plantation Company: Nitrate of soda, 200 pounds per acre. Yes, very beneficial at Kahuku as it appears to assist cane to withstand the wet, cold climatic conditions of this side of the island. The test carried out this year is showing great benefit of this application.

Waialua Agricultural Company, Ltd.: We are opposed to winter fertilization, as it has a tendency to make the cane very soft and more susceptible to sickness.

Kekaha Sugar Company, Ltd.: Sometimes in a dry year. Nitrate of lime in the winter months, with good results. However, only in a dry year in the irrigation water.

Waimea Sugar Company: Depending on weather conditions. In case of a dry, warm winter it gives the cane a quick start in the spring.

Hawaiian Sugar Company: Yes, under certain conditions, it is a great help to backward fields, and in our opinion is worth the expense in certain cases.

McBryde Sugar Company: Yes. Depends on the winter. Think that a ''shot'' in November sends it along through the winter a bit. We start our spring dressing here in January.

Koloa Sugar Company: Some fields which have received very early mixed fertilizer applications show apparent gain in color and growth with additional dose of nitrate in late fall or early winter. We have not done this extensively yet.

Kilauea Sugar Plantation Company: No. It is very dangerous with us, since we get no response in a cold and wet winter.

Lihue Plantation Company, Ltd.: The only winter fertilizing we do is in some late planted field, when we give 200 or 250 pounds of nitrate of soda to stimulte it through the cold weather.

6. How do you apply mud press to plant fields before plowing, to poor spots in different fields, etc.?

Olaa Sugar Company, Ltd.: It depends on the nature of the soil. In some fields it is used for ''touching up'' poor spots, in others it is spread evenly all over.

Waiakea Mill Company: We apply to plant fields before plowing when such fields are adjacent to railroad. Otherwise to ratoon fields. We do not believe in spending large amounts doctoring up poor spots. The same amount spent on good soil will produce double the results.

Hilo Sugar Company: We apply it to plant fields before plowing and to poor spots in all fields as far as is practicable.

Onomea Sugar Company: Our preference is to have it plowed in before planting, but we find it good in every instance no matter how it is applied, only when it is plowed under it saves the forcing of weeds. All surface weeds feed readily on it, hence we prefer

turning it under. We also get good results by applying it in the furrow just before planting.

Pepeekeo Sugar Company: As much as we can get on plant ahead of plowing, the remainder to poor spots or poor fields.

Honomu Sugar Company: To plant before plowing and to poor spots in both plant and ratoon fields.

Hakalau Plantation Company: We get as much as possible on fields to be planted, and also before plowing. On ratoons we spread it in between the rows.

Laupahoehoe Sugar Company: Before plowing; also throughout the different fields.

Kaiwiki Sugar Company, Ltd.: Before plowing.

Hamakua Mill Company: Before plowing to poor fields.

Paauhau Sugar Plantation Company: Mostly by throwing it into the irrigation water.

Niulii Mill and Plantation: To poor spots in fields.

Halawa Plantation, Ltd.: To plant fields before plowing and to poor places, such as hillsides, etc.

Kohala Sugar Company: We apply it on poor spots and plow in, but mostly to young crops in irrigation water.

Union Mill Company: To plant fields before plowing.

Hawi Mill and Plantation Company, Ltd.: To plant fields before plowing.

Hawaiian Agricultural Company: Poor spots. In ratoon fields.

Hutchinson Sugar Plantation Company: ....

Kaeleku Sugar Company: Poor spots in stony fields.

Maui Agricultural Company, Ltd.: ....

Wailuku Sugar Company: To both. Applied to fields convenient for transportation on railroad.

Olowalu Company: Generally on poor spots in fields while portable track is in the field.

Pioneer Mill Company, Ltd.: We would like to apply all mud press to our mauka fields which are low in phosphoric acid, but the handling costs prohibit this. Most of our mud press is spread with manure spreaders ahead of second steam plowing. Poor spots are also touched up with mud press.

Waianae Company: Both.

Ewa Plantation Company: Uniformly by manure spreader.

Oahu Sugar Company, Ltd.: Before plowing; also to poor spots and in water when necessary.

Honolulu Plantation Company: To plant fields before plowing.

Waimanalo Sugar Company: To plant fields before plowing if fields are available; if not, in irrigation water.

Kahuku Plantation Company: 1. To different fields in the water (mostly coral rock sectors). 2. To fields lying fallow. 3. To poor spots.

Waialua Agricultural Company, Ltd.: Prefer applying it to fields before plowing or after the first plowing.

Kekaha Sugar Company, Ltd.: We apply by railroad cars from 10 to 15 cars, or about 10 to 15 tons per acre, and plow under.

Waimea Sugar Mill Company: Either to plant fields before plowing, or to poor spots in different fields.

Hawaiian Sugar Company: We apply it in the irrigation water, and also before plowing.

McBryde Sugar Company, Ltd.: Plowing, but where possible like to get it on poor spots. We often run it in water on poor spots, especially if the fields to be plowed are too far and inconvenient from main line.

Koloa Sugar Company: We apply it with a manure spreader on fields to be plowed and planted.

Kilauea Sugar Plantation Company: Plant fields before plowing; also on poorer spots and palis in ratoon fields.

Lihue Plantation Company, Ltd.: Yes.

Comparative Values of Normal Juice Factors*

By Raymond Elliott

The methods used for determining the tons of cane in a factory where the cane is flumed directly to the crusher necessitates the use of a factor on the crusher or first mill juice brix, so that the various calculations can be made.

We know that as the cane comes to the mill to be ground, it is very difficult to sample because of the widely varying degrees of ripeness. Therefore, on rail and flume plantations the control starts at the mixed juice scales.

It has been found that in flume cane factories the first expressed juice is diluted with water adhering to the cane, and in determining a factor to be used in calculating the weight of the cane allowance has been made for this dilution, that is, the calculated cane weight refers to dry cane or rather to cane minus adhering water, but not water that has been absorbed by the cane, which becomes a part of the juice in its transit from field to mill.

The cane weight on a flume plantation, where a constant factor is used will not vary as on a rail plantation where the cane is weighed. The rail weights will vary according to climatic conditions, trash content of cane and its ability of retaining water. In some cases where there is a flume near the mill, a train of cane may come directly to the scale and be weighed while there is considerable water still dripping from the cars. This extra weight goes in as cane and increases the tonnage of cane, making the ratio of cane to commercial sugar higher. On flume plantations these fluctuations do not occur, therefore, they have the advantage.

The object of the writer is to make a brief comparison of normal juice factors in order that we may see how important this phase of control is. The whole question may be summed up as follows:

First, how important is the normal juice factor?

Second, the weight of cane per ton of sugar being intimately tied up with the normal juice, will the tons of cane per ton of sugar from a fluming plantation be strictly comparable with a factory that weighs their cane?

Third, is there any relation between Java ratio and the normal juice factor?

I have taken an ordinary day's run at Paauhau and calculated the tons cane by using different factors. The table, which is to a large extent self-explanatory, is given herewith:

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

AVAILABLE DATA APRIL 1ST, 1924

Brix of Crusher Juice	17.00
Polarization of Crusher Juice	14.80
Purity of Last Mill Juice (Discharge Roller)	67.82
Purity Mixed Juice	82.66
Fiber per cent Cane	12.81
Moisture per cent Bagasse	37.92
Polarization per cent Bagasse	1.35
Tons Polarization in Mixed Juice	76.91
Tons Polarization in Cane	78.86
Polarization per cent Cane	11.60
Extraction of Polarization per cent Polarization in Cane	97.53
Tons Cane Weighed	679.88
Normal Juice Factor Calculated	95.06
Java Ratio	78.38

CALCULATIONS USING DIFFERENT NORMAL JUICE BRIX FACTORS

Factors Used	92	93	94	95	96	97	98	99	100	101	102	103	104
Normal Juice Brix	15.64	15.81	15.98	16.15	16.32	16.49	16.66	16.83	17.00	17.17	17.34	17.51	17.68
Normal Juice Polarization	12.86	13.00	13.14	13.28	13.43	13.56	13.70	13.84	13.98	14.12	14.26	14.40	14.54
Normal Juice Purity	82.20	82.20	82.21	82.21	82.22	82.22	82.23	82.23	82.24	82.24	82.24	82.25	82.25
Polarization per cent Cane	11.21	11.33	11.46	11.58	11.71	11.82	11.95	12.07	12.19	12.31	12.43	12.56	12.68
Extraction of Pol'n per cent Pol'n in Cane	97.41	97.44	97.47	97.50	97.52	97.55	97.57	97.60	97.62	97.64	97.67	97.69	97.71
Tons Polarization in Cane	78.95	78.93	78.91	78.88	78.87	78.84	78.83	78.80	78.79	78.77	78.74	78.73	78.71
Tons Cane	704.28	696.65	688.57	681.17	673.53	667.01	659.67	652.86	646.35	639.87	633.47	626.83	620.74
Java Ratio	75.74	76.55	77.43	78.24	79.12	79.86	80.74	81.55	82.36	83.18	83.99	84.86	85.68

Inspection of the figures show, that the higher the normal juice factor, the higher the extraction and polarization per cent cane, also less tons of cane, therefore less tons of cane per ton of sugar and furthermore, as the normal juice factor is increased, the Java ratio increases in proportion. Lowering of the normal juice factor reverses the above.

Assuming a 90 per cent total recovery, we have for a 92 normal juice factor, $78.95 \times .90 = 71.05$ tons sugar, and calculated tons of cane per ton of sugar is 9.91 and similarly for a factor of 104 we have $78.71 \times .90 = 70.84$ equalling 8.76 tons of cane per ton of sugar.

The difference, or 9.91 less 8.76, is 1.15 tons of cane, or .09 ton cane per degree increase or decrease in normal juice factor depending on whether the factor is increased or decreased.

If the fiber is decreased, other factors remaining constant, the extraction and polarization per cent cane are increased, with a correspondingly less tonnage of cane, hence less tons of cane per ton of sugar. Increasing the fiber, the reverse is true.

The writer calculated all of the normal juice factors for the different plantations from figures given in the Annual Synopsis of Mill Data for the years 1921, 1922 and 1923. The factors and Java ratios were plotted and agreed very closely when compared year by year. The graph for 1923 is given. Each plantation, however, is not strictly comparable with another for this reason. Some mills report only crusher juice while others report a mixture of crusher and first mill juice. The latter is generally called first mill juice. The crusher juice will roughly represent a juice extraction of 30 per cent while the crusher and first mill may go as high as 30 per cent juice extraction.

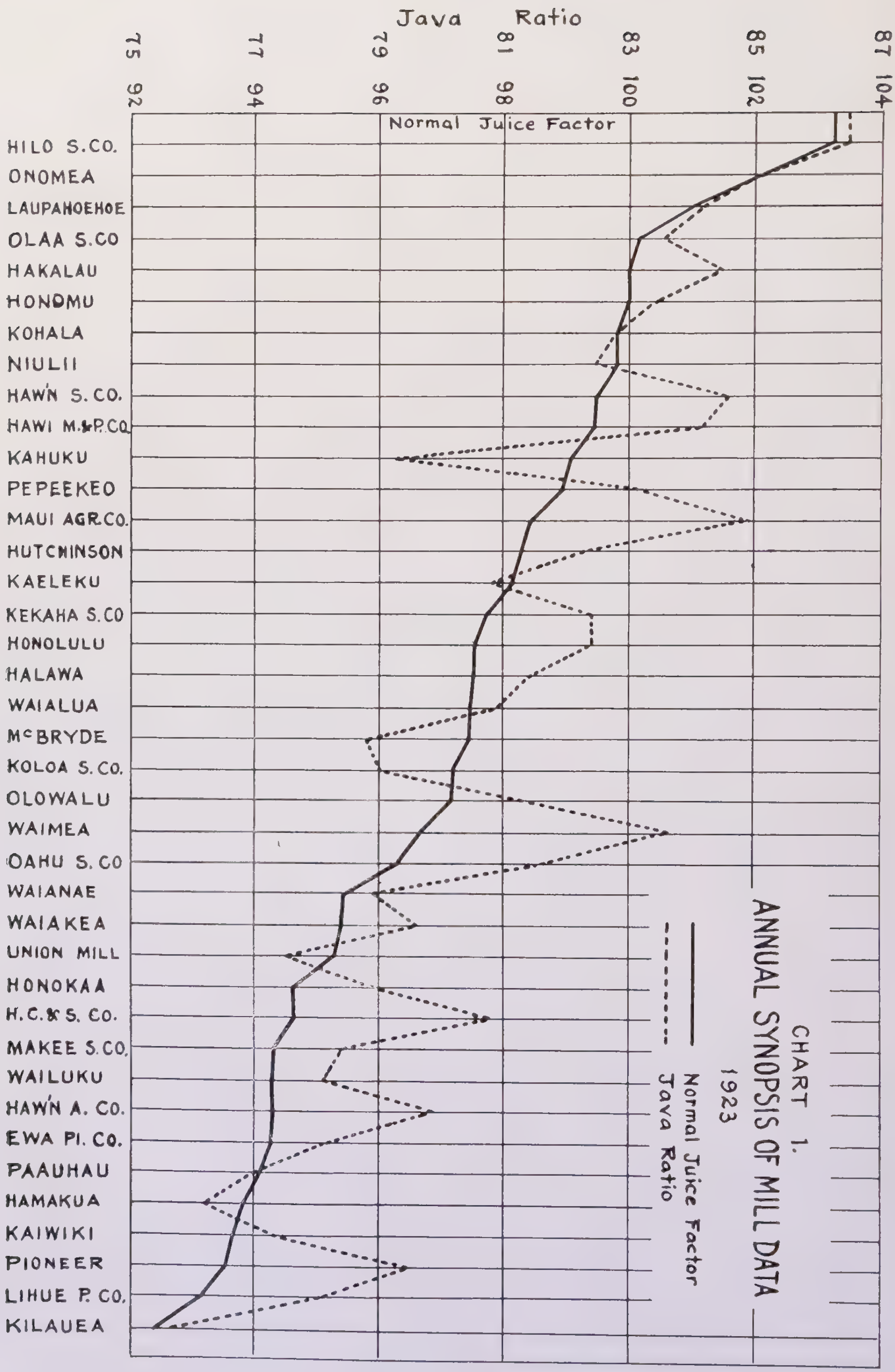
At Paauhau, we have made a large number of determinations to ascertain the difference between the crusher and first mill brix. An average of 97 tests gave the following:

Crusher juice brix	16.81
First mill juice brix	16.48
Difference	.33

On this basis, each tenth in brix would then represent $\pm .59$ in the normal juice factor where the brix is 17.00 and $\pm .50$ where the brix is 20.00. The difference does not seem large, but when calculating tons of cane using these differences, large discrepancies appear.

On a plantation where the cane is weighed, it has been my experience that the calculated factor varies from day to day. Today it may be 94, tomorrow 98, and no visible reason for the change, but, over a long period, comparing crop to crop, the factor is quite constant.

Following are some figures taken from the daily reports at Paauhau. They tend to show that rainfall influences the normal juice factor:


Java Ratio
75 77 79 81 83 85 87
92 94 96 98 100 102 104
Normal Juice Factor
HILO S.CO.
ONOMEA
LAUPAHOEHOE
OLAA S.CO
HAKALAU
HONOMU
KOHALA
NIULII
HAW'N S. CO.
HAWI M.&P.CO.
KAHUKU
PEPEEKEO
MAUI AGR.CO.
HUTCHINSON
KAELEKU
KEKAHA S.CO
HONOLULU
HALAWA
WAIALUA
McBRYDE
KOLOA S.CO.
OLOWALU
WAIMEA
OAHU S.CO
WAIANAE
WAIAKEA
UNION MILL
HONOKAA
H.C.& S. CO.
MAKEE S.CO.
WAILUKU
HAW'N A. CO.
EWA PI. CO.
PAAUHAU
HAMAKUA
KAIWIKI
PIONEER
LIHUE P. CO.
KILAUEA
CHART 1.
ANNUAL SYNOPSIS OF MILL DATA
1923
Normal Juice Factor
Java Ratio

Date—1924	Rainfall in Inches	Normal Juice Factor	Java Ratio
March 24	1.49	99.70	81.66
March 25	.02	100.32	81.85
March 26	.01	98.82	80.50
March 27	.00	97.70	77.86
March 28	.36	94.62	79.31
March 29	.05	98.73	80.14
April 1	.00	95.06	78.38
April 2	.00	95.55	79.58
April 3	.00	95.76	77.17

When we have dry weather at Paauhau, generally the factor varies between 95 and 96, but as soon as it rains the factor rises. I think this may be due to the first expressed juice being diluted, hence a lower brix and polarization, the purity remaining constant. The total polarization in the cane would be the same as before.

I would not say that rainfall had everything to do with the variation of the factor. There are other conditions which to a greater or lesser extent influence the above, for instance, whether the cane is plant or ratoon, variety, damaged cane by rats and borer, irrigated vs. non-irrigated, etc.

The true average of 25 complete dry crushing tests at Paauhau gave a 95.17 normal juice factor based on the crusher juice. The same calculated on the combined crusher and first mill juices gave 96.67.

Summing up, in answer to the first question as to the importance of the normal juice factor, I would say that as far as the comparative value of the normal juice factor is concerned, it is quite useless to compare factory against factory under the existing conditions. If all factories were operating exactly alike, then the factor would be one of the most important figures that we could have in the chemical control for cane sugar factories in Hawaii.

To the second question, as long as flume cane factories calculate their cane weights and all use different normal juice factors, their tons of cane per ton of sugar will not be comparable with those factories weighing their cane.

Lastly, the Java ratio is important as there is a direct relationship between the two figures.

In concluding this discussion on normal juice factors, I think more time, attention and thought should be given this important subject and that its value be frequently determined by all plantations on a uniform basis.

Report on Mill and Boiling House Installations and Activities in 1924*

By Arthur F. Ewart

In the early part of July letters were addressed to a number of mill engineers asking for a list of new machinery that was being installed in their factories this year, also for any other information that would be of interest to the members of this Association.

The six replies received form a part of this report.

J. Lewis Renton, of Ewa Plantation Company, writes:

The new machinery added to the Ewa Plantation Company factory this year has not been very extensive.

The main engine of the second mill train, which was a 28″ x 48″ light Corliss, was replaced by a heavy duty 30″ x 54″ Corliss, and the new engine is giving perfect satisfaction as well as increasing our recovery by being able to carry the load as now determined by Hawaiian mill practice. The variation from the standard 30″ x 60″ engine for a nine-roller mill unit was deemed advisable as this engine drives the second mill train, which operates at a comparatively high speed especially with our high grinding rate and to keep the piston speed within limits of good practice it was necessary to shorten the length of cylinder.

An electric magnet was installed back of the first nine-roller mill unit to remove iron from the bagasse blanket before entering the second nine-roller mill unit. The magnet was made part of the discharge roll scraper and set at an angle of 45°, and was very successful in catching and holding practically all of the iron and steel passing this point. This assortment was the accumulation of three months' grinding and weighed over 300 pounds. From the experience gained with this installation I do not at present see any hope of removing iron or steel preceding our mills or even early in the mill train, except at some point where a thin blanket of dry, finely divided bagasse is made to slide down an incline. These limitations make its adoption almost impossible except in those mills where such a condition does exist. I might add, that with our heavy tonnage, most of the damage to the rollers and the grooving from pieces of iron occurs in the second mill train.

Boiler feed water regulators of the Copes manufacture were tried out on four of our boilers and gave such excellent service that they are to be placed on all of our high pressure boilers. One advantage of this type of regulator is its simplicity, the only working part being the boiler feed valve itself and the lever to it. A fusible disk type of low water alarm is being used also.

Water meters were installed on the boiler feed, maceration water line, and the mud press wash water line. These are very satisfactory and a great help in the work and control of the factory.

The milk of lime for liming at the mixed juice scales, is now being circulated and mixed with an air lift operated by compressed air. While not as efficient mechanically as other means of circulation now employed, provided the other equipment is kept up mechanically, it probably pays for itself in cost of upkeep and average efficiency.

An attachment to our cane scales on the empty car side has been tried out for the past several months, same being an automatic registering device which will give direct

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

readings of from 0 to 5,000 pounds, and has given such a good account of itself that an order has been placed for another for the full car scale. In case of disability, the attachment can be disconnected and weighing with the beam scale taken up. The automatic attachment is not very expensive and seems to be doing accurate work as well as enabling the scale man to be more accurate in his reports.

J. Meinecke, of Maui Agricultural Company, Ltd., writes:

The following is a list of new machinery being installed at Maui Agricultural Company, Ltd., this season:

1 Westinghouse steam turbine direct connected to 1500 k. w. generator, turbine running 3600 r. p. m. condensing on an Alberger condensor.

1 Guild and Garrison juice pump 12″ x 12″ x 20″.

1 Cameron boiler feed pump 16″ x 10″ x 33″.

1 Double friction steel hoist for cane cars.

1 One hundred horse power motor for revolving cane knives.

1 One hundred and fifty horse power motor for revolving cane knives.

1 Eighty-eight-tooth, 4½″ pitch, 18″ wide mill gear.

1 Honolulu Iron Works mill, consisting of 2 cast steel cheeks with Honolulu Iron patent steel caps and cast steel returner bar for 7th mill.

4 Honolulu Iron Works patent steel caps for 5th and 6th mills.

12 New cast iron mill rollers 34½″ x 66″.

2 Eight hundred horse power Stirling boilers to carry 160 pounds steam replacing 6-7 x 20 tubular boilers. The factory will have a total of 3900 boiler horse power consisting of four 800 horse power boilers and two 350 horse power Badenhausen boilers, all to furnish steam at 160 pounds pressure for Westinghouse steam turbine and 125 pounds steam for factory through Mason regulating valves.

2 Ten-inch double automatic Lagonda steam valves.

2 Ten-inch Mason regulating valves to regulate pressure from 160 to 125 pounds.

R. B. Kay, of McBryde Sugar Company, Ltd., writes:

Our only new installation during the past crop was a Peck strainer, which gave very satisfactory results. A detailed report of the strainer will appear under "Raw Juice Straining."

New machinery being installed this year includes a 15-ton Niles electric crane, a new machine shop and a lathe capable of turning our own rolls. The machine shop is actually a cotinuance of the mill, and the electric crane will enable us to lift the roll direct to the lathe. From this arrangement we anticipate a considerable saving in labor and time.

George Duncan, of Olaa Sugar Company, Ltd., writes:

I am afraid I cannot give you any assistance on the above topic, as there is nothing new or contemplated at Olaa.

A subject that has received very little attention, it seems to me, is that of fuel economizers. Why is it they are not used, especially in places where they are troubled by the lack of fuel? Even in new factories their use is not contemplated. There must be some reason for this. What is it?

Maybe we may hear something at the meeting that will throw a bit of light on this.

W. van H. Duker writes:

Crusher Roll Design: The ordinary crusher roll consists of a shell fastened on a steel shaft. Keying up of the shaft requires much time and needs to be done with the greatest care and accuracy, as otherwise it may happen that the shell works loose.

The maker is expected to deliver such work under the highest guarantee, that is, when both shell and shaft are furnished by him. When this is not the case and when a new shell is to be fitted to an old shaft, or vice versa, he cannot assume the same responsibility because the quality of the material is then unknown to him.

The charges for putting on a new shell are often considered high, but when realizing the painstaking effort and skillful work required, it is clear that such work can only be done by expert and high-paid labor.

The location of the keyway in the pinion on one roll is done after the keyway in the other roll has been fixed, because the pinion must be so fitted that the corrugations on the shell and the teeth on the pinion correspond in their relative positions.

When the pinion has as many teeth as the shell has rows of corrugations, the key is placed opposite the center of a tooth in such a way that the center of the pinion tooth corresponds with the center of the corrugations on the shell.

The shape of the corrugations of the crusher shell has a decided influence on the quality of the crushing. In the illustration, Fig. 1, the space lettered A over 1 and 2

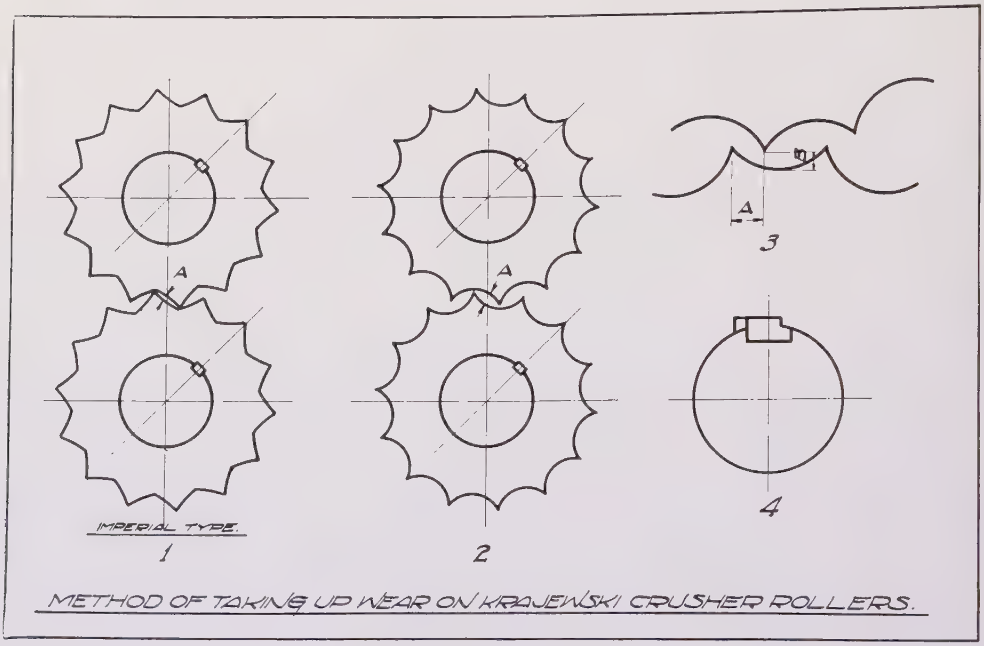


Fig. 1

is much smaller in the imperial type and the reabsorption of already removed juice is bound to be less.

When the corrugations on the shell are badly worn, the distance "A" can be reduced by changing the position of the pinion teeth in relation to the corrugations on the roll; this is done by using an offset key in the pinion, as shown in the illustration.

I present this case at the risk that I am repeating something considered as generally known, but I wish to add that this is an example taken from actual milling experience. At Hamakua Mill Company, this was exactly the case. For years the extraction obtained with a crusher and 12-roll mill remained at about 95 per cent. Many suggestions were made, many improvements executed; but the results were not changed. The crusher was badly worn and generally condemned until the local engineer, Wm. Craik, shifted the pinion on the shaft in the manner described above. From that time on entirely different milling results were obtained. I would say an average increase in extraction of between 1½ per cent to 2 per cent.

Mr. Seymour Terry writes:

Modern Evaporating Methods: Publications devoted to Sugar News point out a tendency in the European beet industry to discard our well established vacuum type evaporator in favor of pressure evaporation. The indication is that all new European beet factories under construction and contemplated will install evaporators operating at a pressure in the cells in place of a vacuum. They claim a saving of as high as 25 per cent of fuel used in certain cases by the adoption of this method of concentrating against the old method. It is natural that developments toward fuel saving should emanate from European beet factories when consideration is given to the fact that a beet factory has to purchase all the fuel used generally in the form of coal or oil, and Europe cannot afford to leave any suggestion of possible economy uninvestigated. Czechoslovakia is the most advanced in this new method of concentration, but Europe in general is prepared to discard the old for the new where conditions will allow of it. It is not the intention of this article to imply that any revolutionary changes can be effected by applying this system to our cane sugar factories, but simply to draw attention to what at this time is the leading topic in the camp of our beet sugar competitors.

It will be interesting to first set down the principle of operation of an evaporator.

In our standard multiple cell evaporator, we introduce steam into the calandria of the first cell, which steam contains both sensible and latent heat. We draw off the condensate at the temperature of the steam leaving behind the latent heat. This latent heat passes through the tube system and converts the liquid in the juice space into steam. This cycle is repeated for however many cells are used, such as four times in a quadruple effect evaporator. In order to have this latent heat pass through the tubes and do its work on the liquid it is necessary to have a difference of temperature between the heating steam and the liquid. This is obtained by using a condenser operated by cold water and an air pump to produce as low a temperature as possible in the last cell. The higher the vacuum the lower the temperature. The greater the temperature difference between the inlet steam and outgoing vapor or the overall temperature drop of the evaporator, the more work will be done by the evaporator. However, the act of condensing the vapor from the last cell throws into the discard all the remaining latent heat in the vapors.

In pressure evaporators it is general to use three cells as a triple effect operating at about 16 pounds pressure in the calandria of the first cell down to 1½ to 2 pounds in the vapor side of the last cell. This steam from the last cell is then used in the vacuum pans which operate at a vacuum as at present. The amount of steam required by the pressure triple evaporator is, of course, more than would be used in a quadruple operating at a vacuum, but in that it is discharged at such a pressure as to be of further use in the vacuum pans, a considerable steam saving is made. In this way, a unit consisting of a pressure operated triple supplying steam to the vacuum pans shows a large decrease in steam consumption over a quadruple and pans both operating at a vacuum. This new method gives a higher steam temperature and a correspondingly higher syrup temperature. To avoid discoloring the syrup, rapid circulating evaporators having a high transmission coefficient are used so that the concentration is rapid, and the time the liquor is in the apparatus short, which also means that the amount of liquor in the body at one time is much less than at present. Due to the condition that exists in syrup in that as the temperature increases, the viscosity rapidly decreases, a higher rate of evaporation is obtained for a given temperature drop at the higher temperatures of operation in the pressure evaporator. Incidentally, the engines supplying the exhaust steam to the evaporators have to work against a back pressure of 16 to 18 pounds per square inch.

Another phase of the evaporation problem which is being studied at this time is vapor compression described as follows:

The heating steam enters the calandria of the first cell and the condensate is drawn off as usual. The vapor produced from the liquid in the body of the cell and which is at a lower temperature than the heating steam, depending on whatever temperature drop the cell is operated at, is taken from the top of the cell and put through a vapor com-

pressor where it is compressed up to the pressure and therefore the temperature of the initial heating steam.

The methods employed to compress the steam are shown in Fig. 2:

A shows the standard quadruple evaporator as used in Hawaii in which the difference of temperature in the different cells is obtained by vacuum apparatus.

B shows a motor driven vapor compressor.

C shows a steam engine driven vapor compressor.

D shows a steam injector using live steam to compress the vapor.

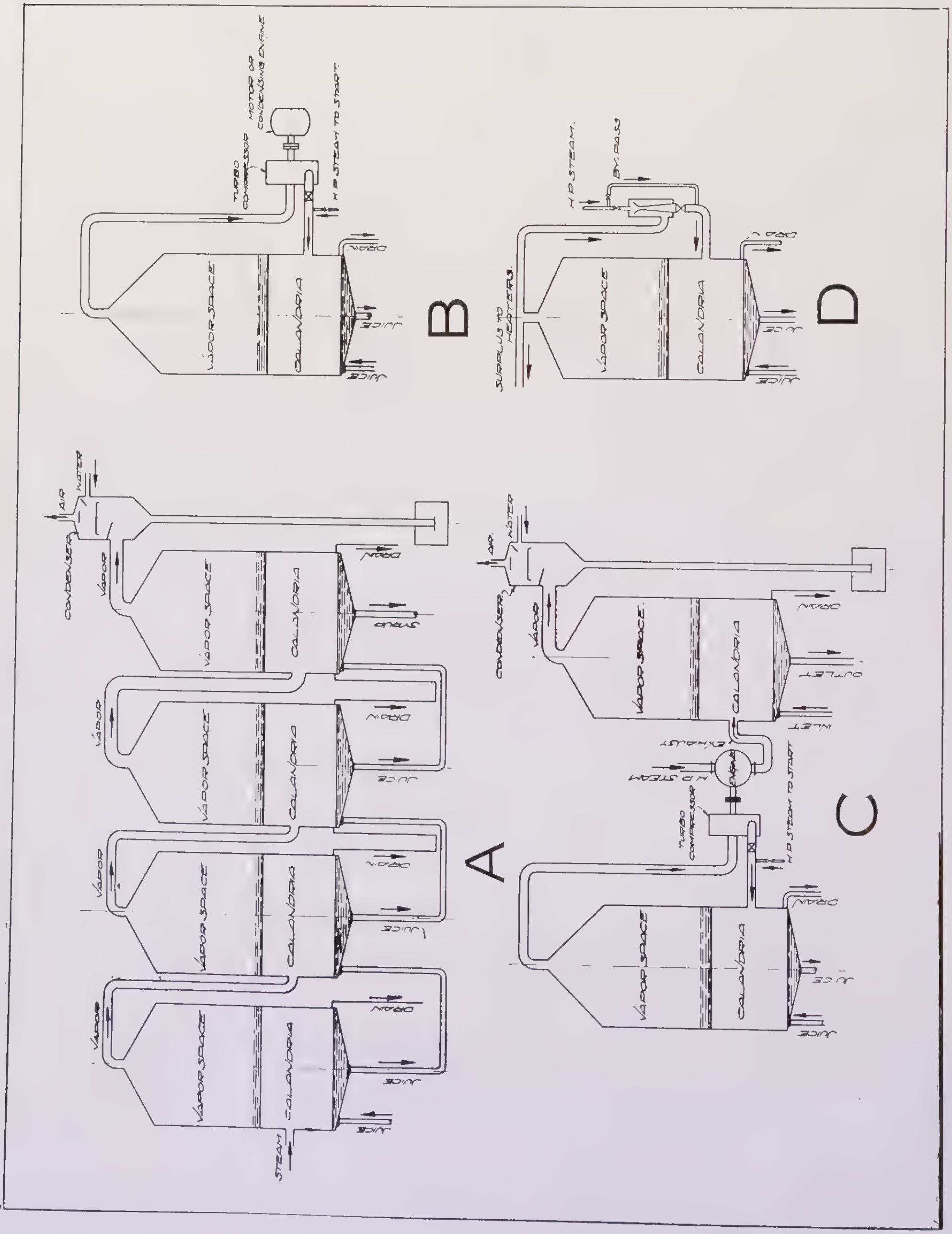


Fig. 2

The greater the amount of work obtained from a pound of steam, the lower the compression pressure, but this means a small temperature difference and large heating surface. The practical range appears to be about 7 pounds, or a temperature range of 12° F.

The New York division of the Honolulu Iron Works Company recently made an installation of three large injector type compressors, also known as thermo-compressors, on the first cell of a quintruple effect for Los Mochis cane sugar factory in Mexico. They inform us that they had tests made and found the efficiency to be about as high as possible for this type of compressor. The compressors were supplied with live steam at 100 pounds gauge and each pound of live steam compressed 1.2 pounds of vapor from 3 pounds gauge pressure to 8 pounds gauge pressure thus supplying 2.2 pounds of steam to the calandria. These 2.2 pounds in the calandria would evaporate about 2.2 pounds of vapor so that 1 pound of live steam resulted in the production of 2.2 pounds of vapor which is slightly better than a double effect pre-evaporator.

Centrifugal Separators: Centrifugal separators have come into use again this season. They have done good work in separating liquor from the solids in settlings.

Settlings from ordinary settling tanks, the Petree-Dorr process, or from any other subsider, may be separated in these centrifugals.

They are particularly advantageous in cane sugar factories, where the mixed juice is strained through very fine screens and the fibrous matter removed.

Settlings, devoid of fibrous matter, can only with difficulty be separated in filter presses, on account of their gummy, smeary nature. In centrifugal separators this condition is no hindrance.

The separation in a centrifugal of 40-inch diameter and 24-inch deep takes place at a rate of flow of 25 to 30 gallons per minute, when the speed of the machine gives a centrifugal force of about 500 gravity. It is within safe limits to increase this force to 800

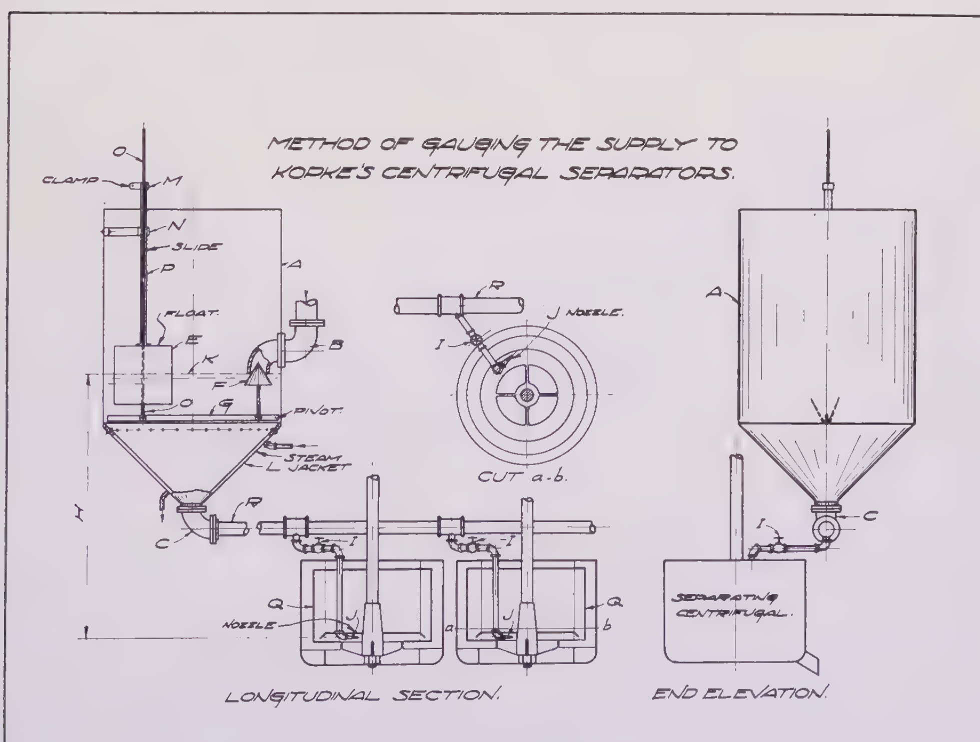


Fig. 3

gravity and by this the capacity of the machine is increased and the clarity of the run-off improved.

With centrifugals separating settlings, the aim has been for a large volume rather than a very clear run-off. The run-off is returned to the unclarified juice.

The construction of the centrifugal separators has undergone some modification since its first introduction some twelve years ago.

The suspended machine with independent electric, or preferably water drive, is now used. The revolving bowl is accurately machined inside and out. The run-off liquor is continuously sampled by having a small stream run over a lighted glass plate.

A very important addition to a centrifugal separating plant is a flow regulating tank. This is illustrated in Fig. 3.

The object of this tank and its fittings is to supply each machine with a constant quantity of unseparated liquor (settlings).

There are two means of regulation. The float may be raised or lowered and fastened in any position thereby increasing or decreasing the hydrostatic head and the flow into the centrifugals. Further regulation can be made by using larger or smaller nozzles "J," discharging directly into each of the revolving machines.

The tank "A" has a conical bottom and is shown here with a steam jacket. It is essential to have the settlings hot for efficient separation. This steam jacket (or steam coil) gives the means to heat the settlings if required before entering the separators.

The accumulated mud cake in the bowl is discharged with an unloader similar in construction to a sugar unloader.

The mud cake is mixed with water to reduce it to any desired sucrose content and is reseparated. The amount of water required is considerably less than is required in filter press work because in mixing the mud, the water comes in intimate contact with every particle of the cake and brings about nearly perfect diffusion, while in a filter press the sweetening-off water or steam is apt to channel through the cake and not come in contact with all sucrose containing particles.

Another factor in favor of centrifugal separation is the comparatively short time required to exhaust the cake of its sucrose. The run-off is quickly returned to the process of manufacture instead of becoming inverted through long exposure.

The saving of heat, sugar from inversion, labor, filter cloth, evaporation through the reduced amount of sweetening-off water, etc., was reported on by Dr. R. S. Norris and appears in the Report of the Committee on Manufacturing Machinery, page 17, in the H. S. P. A. Proceedings of the Forty-first Meeting.

This report itemizes the saving in centrifugal separation over filter press work under the numerals 2, 3, 4 and 5, and are, as far as these items lend themselves, to be expressed in money value as follows:

2. The saving of 75 tons sugar a year (on a 6,600-ton crop) lost by fermentation in filter pressing, say	$ 6,750
3. The saving of $500 a year in filter cloth	500
4. The saving of $600 a year on labor	600
5. Less evaporation on account of smaller amount of water required for washing the mud in the centrifugals than for cake in the presses	Undetermined
Total	$ 7,850

The items 2, 3 and 4 alone show a saving of $7,850 a year on 6,600-ton crop. If one figures the saving on larger crops in the same proportion, one hesitates to accept the figures. For instance, on a 30,000-ton crop over $35,000 would be saved, and Dr. Norris was conservative in his figure.

Old and Modern Settling Tanks as Used in Raw Cane Sugar Factories

In all settlers, whether of the old style 500-gallon rectangular tank with steam pipes in bottom and scum trough on top, or the modern continuous settler, the

aim is to have as complete a separation as possible of the three substances: scum, clear liquor and solids.

The old style clarifier was liming tank, heater and settler combined.

It did good work but on account of loss of heat, large space required and laborious hot work and sloppiness it had to make room for more economical devices.

The modern juice heater was introduced in Hawaii in the early nineties, and settlers of various shapes appeared. Liming, heating and settling are now done in separate apparatus.

Of the many settlers introduced, the Deming was perhaps the best known. Noel Deerr describes it (see Fig. 4) in his book of 1905, page 152, and investiga-

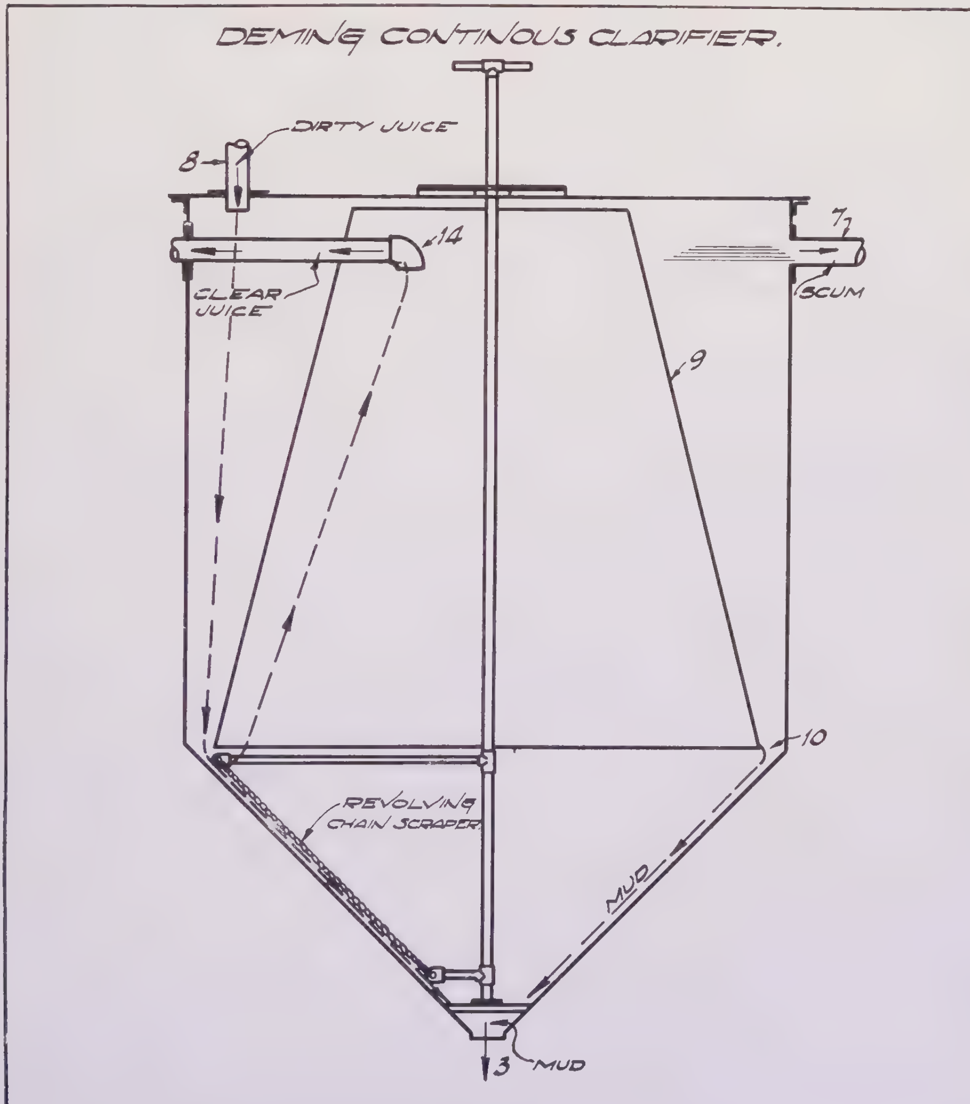


Fig. 4

tion of its work showed it to have been superior to the then existing settlers. Same book, pages 152, 153, has reports by Beeson, Edson, and Geerligs.

Figure 4 shows elements of successfully working settlers of the most modern type.

This design embodies the idea of inducing the lighter impurities wax, gums or scums to rise to the top and flow out in the most direct and undisturbed way. It induces the juice with the heavier impurities to a region low in the tank so that these impurities, by the action of gravity, pass on to the narrow bottom and allow, at a very slow rate of flow, the clear juice to rise to the upper part of the tank where it is drawn off.

The modern settling tank (Fig. 5) has all these principles, but has a number of cones instead of one, thereby multiplying its efficiency and capacity. Cross sections have been proportioned for the most advantageous juice velocities and the concentration of the heavier impurities in the funnel shaped, acute angled bottom.

Figure 5 shows a vertical section of a modern settler for cane juice. It is superior in effectiveness and simplicity to most of the preceding designs.

Its operation is as follows: Dirty juice enters the tank through pipe 8. The scums rise to trap 6 and flow out through pipe 7. From the descending juice the heavy impurities strike baffles 9, travel down on the steep decline and in a concentrated state, through openings 10. The juice travels at a very low velocity up to the discharge pipe 14. The remaining heavier impurities have a chance to settle out before reaching the discharge.

The clear juice finally flows into rending tank 17. The tank is provided with regulating valves from each compartment and delivery pipe for the clear juice.

An important feature of this settling tank is the very steep slope of the cones assuring the downward movement of precipitates. In the lower cones, mechanical means are employed to move and compress the heavier and more concentrated precipitates toward the mud discharge 3.

As indicated in Fig. 5, the mechanism of the revolving parts is compact and simple.

Unstrained Juice Pump

At the second annual meeting of the Association of Hawaiian Sugar Technologists, the use of an unstrained juice pump in Oahu Sugar Company's factory was brought up and mentioned in the report of that session on page 104.

Under the care of the Oahu Sugar Company's engineering staff a new type of valve has been developed in this pump which has worked successfully during the seasons 1923-1924 and is now beyond the experimental stage.

The object of such a pump and the persistency with which it has been brought to working perfection during the last two seasons were prompted by the fact that the juice strainer, as commonly used here and in other cane sugar countries, has some very objectionable features.

Through the intimate mixture of the juice with air (that occurs in the strainer) souring is induced which causes a loss of sugar by inversion, and further, the screenings containing the lowest density and lowest purity liquor

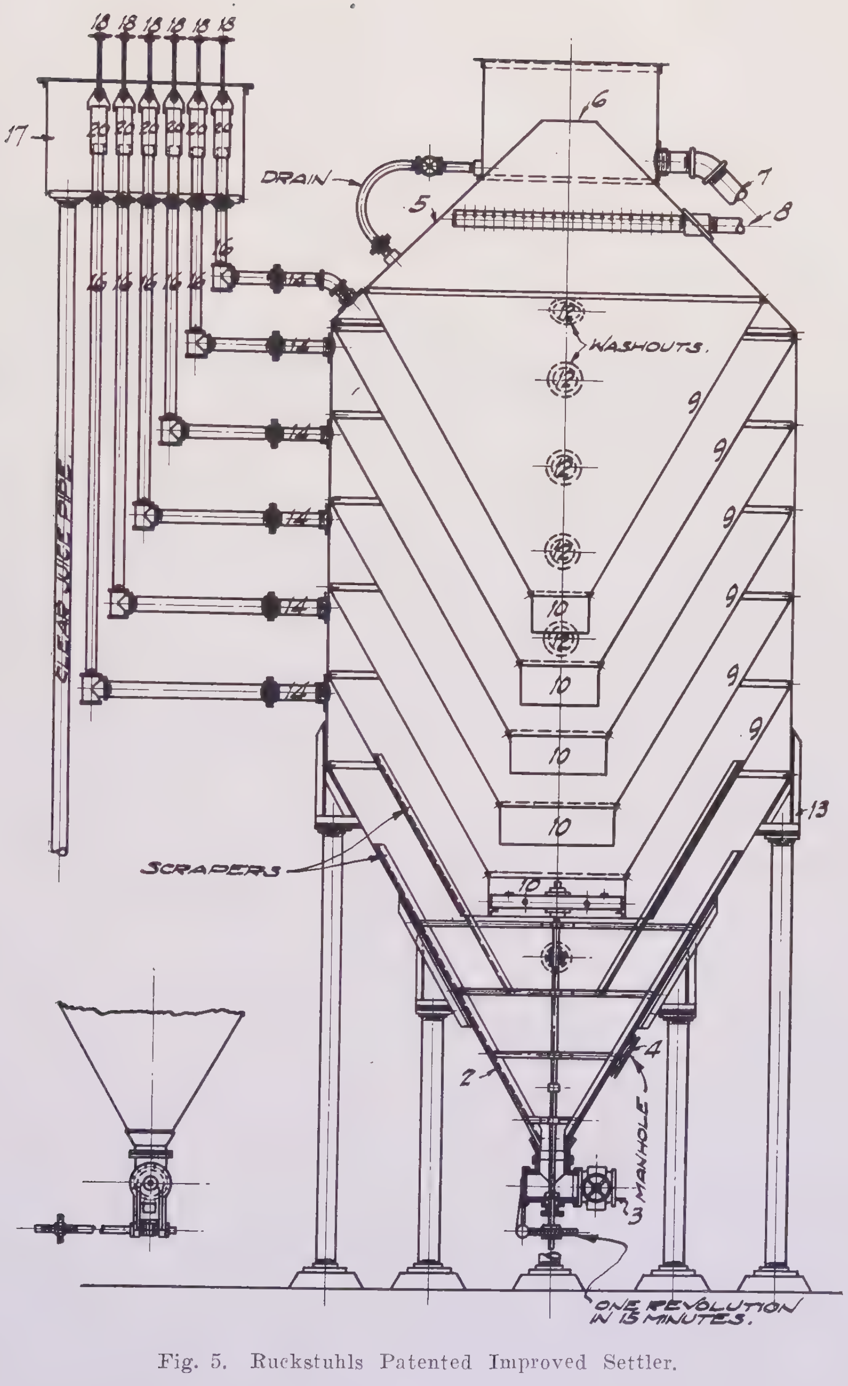


Fig. 5. Ruckstuhls Patented Improved Settler.

are dragged by the slats over the perforated brass screen from the last mill through the discharge of juice of higher density and purity of the preceding mills until it reaches the inflow of the normal juice from crusher and first mill.

The low density and purity juice in the screenings of the last mill is displaced to a large extent by richer and purer juice and this passes through the mills with the bagasse blanket.

By this the rich pure juices are contaminated and the maceration enriched.

These two very objectionable features are, if not entirely, to a large extent eliminated by the use of the unstrained juice pump. W. L. McCleery, of the H. S. P. A., made the following statement at the Sugar Section of the Pan-Pacific Conference:

> In a series of tests on the increase of acidity per 100 density through both tandems at Oahu factory, I found considerably less increase in the mill with the unstrained juice pump than in the other mill equipped with the usual strainer.

Juice Strainer and Mill Juice Tank

Figure 6 shows the cross-section of a juice strainer and mill juice tank designed by E. W. Kopke, of Manila, that is much favored in the Philippine sugar factories.

This design should prove to be useful anywhere, especially where the troublesome jelly-like Leuconostoc forms and causes loss of sucrose and obstructs the flow of juice.

In Fig. 4 is a tank which extends the horizontal length of the strainer and serves the purpose of mill juice tank and supports the super-imposed juice strainer "B."

The strainer is of the slat-scraper type, as commonly used, but has the perforated sheet brass strainer made up in removable sections or panels "C."

The tank "A" is wider than the slat scraper.

By removing the covers "D" any or all strainer panels can be removed and every part of the apparatus becomes accessible.

A person may comfortably enter the tank for cleaning purposes.

Besides the feature of accessibility, the apparatus has a system of steam pipes (not shown) by which the whole apparatus can be thoroughly disinfected.

Lubrication

Lubricating Ball and Washer Bearings of Sugar Centrifugals: This, due to two noticeable reasons, is the source of much trouble in local factories. The first and most important cause for bearing failures of centrifugal driers is due to use of the wrong kind of lubricant. An oil consisting of a medium grade of engine oil, with which there is blended about 15 to 20 per cent acidless or winter strained lard oil has been found to give best results on both types of sugar centrifugal bearings.

In some cases, a medium hard grease is being used as lubricant for the ball bearings. However, unless bearings are completely packed with the grease, and grease does not creep or flow to balls and races, there is simply a groove cut

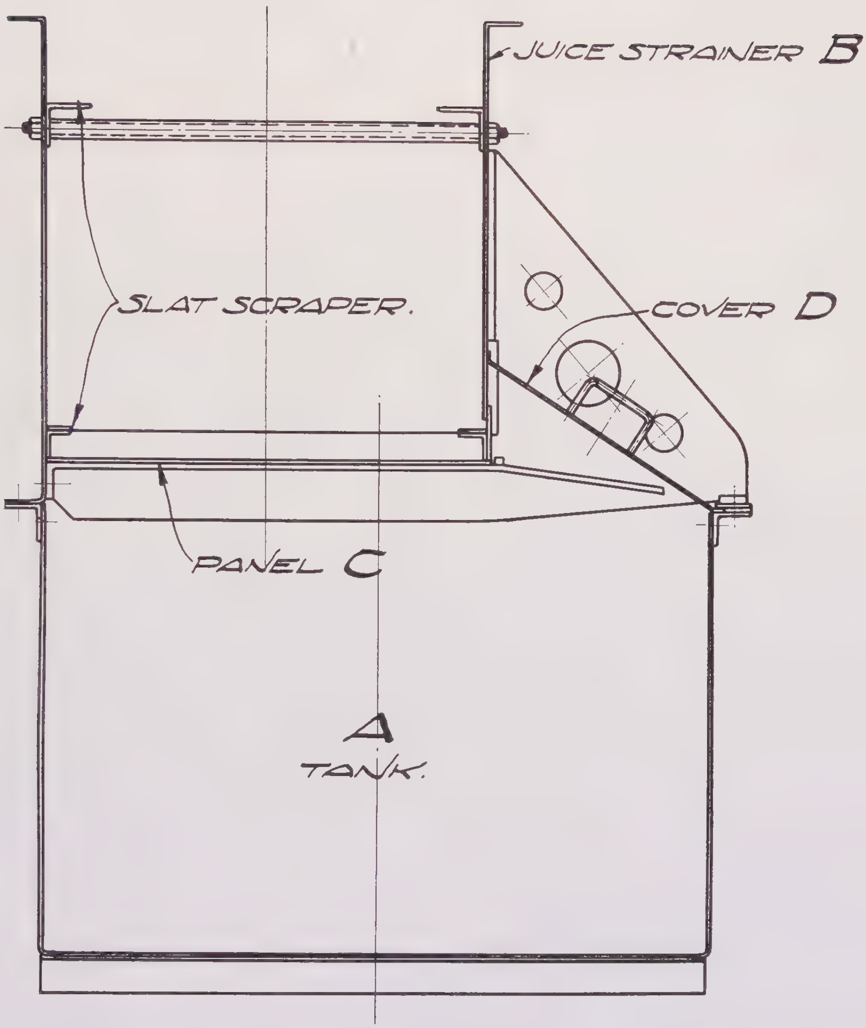


Fig. 6. Cross Section of Juice Strainer and Mill Juice Tank.

through the body of the grease and bearings are soon operating metal to metal, which, it is obvious, will quickly set up a cutting of races and scoring and chipping of balls. When such a condition once develops, there is no lubricant which can lubricate bearings, consequently the destruction of the bearings gradually increases to a point where replacement of balls and races becomes necessary.

Since all ball bearings are surrounded by leak-proof encasements, it is clear that an oil would be eminently more reliable than any solid or semi-solid lubricant.

Reference to the special item of sugar centrifugal lubrication brings to the writer's mind a thought regarding the question of general sugar factory lubrication. Are there not too many different grades of oils being used? This question is asked with the full knowledge that a great many members of our association, have for varying periods regularly used lubricants in sugar factory operation, and are more familiar with the subject than others of us who have accumulated

our opinions in this connection by observing condition of machinery which has either failed or its efficiency unnecessarily impaired by improper lubrication.

Some machinery failures have, no doubt, been due to selection of improper grade of lubricant at time of purchase, or by oilers taking their supply from wrong containers. It is this thought which prompted the query: "Are there not too many different grades of oils being used?"

Would it not be better to use say three grades of oil for sugar factory lubrication? Take for instance a good grade of steam cylinder oil, carrying sufficient compounding to efficiently meet the lubricating requirements in all types of steam cylinders operating at steam pressures between 95 and 125 pounds per square inch. There is sufficient compounding in this type of cylinder oil to give excellent roller-bearing lubrication. It could also be used in worm drives and in all other bearings where it is determined from practice that a heavy oil is required.

Next, a medium grade of so-called high speed engine oil could be successfully used on all types of sleeve and ring oiled bearings. This would include bearings of engines, steam turbines, dynamos, motors, centrifugal pumps, etc. These two grades, with the special oil for sugar centrifugal bearings, could be made to fully meet all lubricating requirements of the average sugar factory and would practically eliminate the possibility of oilers and engine tenders using the wrong oil.

This is simply a thought expressed for the consideration of our members, and while it may appear to many as being somewhat radical, the writer's experience from standpoint of shop observation and shop work, prompts him in submitting it as another step in the direction of safe and economical sugar factory operation.

Supplementary to the foregoing, it might be well to record here the importance of using a good and dependable grade of lubricating oil. By selecting oils of reputable quality rather than because of their cheapness, there will be eliminated many expensive repairs and shut-downs now directly traceable to improper lubrication and improper selection of lubricants.

String Proof Boiling*

By F. D. Bolte

The standard method of boiling low grades string proof in Hawaii is to boil the first molasses over twice, producing three grades of sugar, the second and third sugar being remelted or used as seed for the shipping of sugar and the third molasses discarded as final molasses at about 40 gravity purity.

This has been the system used here at the Hutchinson Sugar Plantation Company for many years, and Table I gives our average purities, etc., for the last five years.

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

For several months I have tried to do this low grade boiling in one stage only and have boiled the second massecuite to about 94 brix, run same into our cooling tanks of 500 cubic feet capacity each, and after about a week pumped three of them to our larger storage tanks and dried this massecuite after about 30 days, giving the results as shown in Table II, viz: a molasses of 42.7 gravity purity which we have discarded as final. We have discontinued using our small coolers and cars with this new system as the massecuite cools off too rapidly in them for this high density work.

We have thus obtained a final molasses of 42.7 gravity purity in 34 days in one boiling, against previously a final molasses of 42.3 gravity purity in 72 days in two boilings. This is a great saving in time, reduces our stock on hand considerably and gives us more centrifugal capacity, as we boil and dry our low grades only once against twice previously.

Complete check analyses of our final molasses from average monthly composite samples made by the H. S. P. A. Experiment Station is, for the years 1923 and 1924, as follows:

Year	1923	1924
Total Solids	73.36	74.10
Gravity and Suspended Solids	82.54	83.06
Sucrose	34.14	35.25
Gravity Purity	41.36	42.44
True Purity	46.54	47.57
Glucose	11.44	11.59
Ash	10.40	10.97
Glucose/Ash Ratio	1.10	1.06

The above low glucose-ash ratio very probably partly accounts for our high molasses purity.

I certainly know that our molasses must be brought to a lower purity to make this one boiling system a success and am now continuing work in this direction.

TABLE I

Old System, Two Boilings

	II Massecuite		II Molasses			Age		
Year	Brix	Purity	Brix	Purity	Drop	Days		
1920	88.0	55.1	84.2	42.0	13.1	15		
1921	88.3	55.5	83.0	42.1	13.4	21		
1922	88.9	52.2	83.9	43.6	8.6	17		
1923	89.3	51.6	86.3	42.4	9.2	22		
1924	90.1	54.8	87.0	43.9	10.9	15		
							Total	Gravity
	III Massecuite		III Molasses				Drop	Purity
1920	92.6	43.0	81.9	31.0	12.0	92	24.1	40.26
1921	92.3	43.5	83.1	32.1	11.4	135	23.4	42.02
1922	91.5	44.0	83.0	35.1	8.9	73	17.1	42.49
1923	93.5	43.8	82.6	35.9	7.9	81	15.7	41.76
1924	94.3	44.7	84.4	37.3	7.4	57	17.5	42.32

TABLE II

New System, One Boiling Only

Date Boiled	Massecuite Brix	Massecuite Purity	Date Dried	Days Old	Molasses Brix	Molasses Purity	Drop	Gravity Purity
July 23	94.1	47.9	Aug. 29	37	85.2	36.6	11.3	42.9
July 26	93.9	51.5	Sept. 2	36	84.0	37.5	14.0	42.5
Aug. 2	94.0	47.6	Sept. 4	33	84.7	36.9	10.7	42.5
Aug. 6	91.7	53.3	Sept. 8	33	83.0	37.1	16.2	42.8
Aug. 9	94.3	52.3	Sept. 11	33	83.0	37.4	14.9	42.8
Aug. 14	94.0	52.5	Sept. 15	32	85.2	37.0	15.5	42.7
Average	93.7	50.8		34	84.2	37.1	13.7	42.7

Boiling House Methods*

By B. B. Henderson

Reports on boiling house methods have been presented to the factory men of these Islands for so many years that it becomes exceedingly difficult to find a new subject to come under this head or even a new approach to an old subject. As a result, reports are now largely a matter of repetitions. However, this does not alter the value of the intention back of these reports, which is, the exchange of information. And as long as results from different factories vary, just that long will the exchange of information be of value.

The boiling house report this year is largely devoted to three subjects, Press Work, Low Grade Work and Commercial Sugar Boiling. Where possible these subjects will be freely supplied with figures showing actual results; the aim being an attempt to arrive at conclusions on a basis of figures rather than opinions. It is hoped that the figures will have a further use as a matter of reference to those who contemplate changes in methods and want to know what might be expected under certain conditions.

Press Work

Pepeekeo Sugar Company: I find that to get a low polarizing press cake, the presses should be tight and the forming of the cake should not be at a greater pressure than 25 pounds. Over three hours washing with water is unnecessary, as a further washing may give a low cake, but a high undetermined loss.

Pioneer Mill Company, Ltd.: Our capacity at this station is much below standard. When grinding 90 tons per hour we have less than three and a half hours available for a complete cycle and less than this when grinding cane from makai fields. I think the reason that we are able to do good work at this station lies in the large amount of cush-cush in the mud and in the fact that the presses are filled at a very low pressure, by gravity, at about 10 pounds pressure. This means that the frames are filled evenly and

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

all parts of the cake are permeable to wash water. It is very rare here to see a cake that is not firm or one that has channeled. The small pressure does not mean that the presses are only partly filled, as they average 1.5 tons of mud per press. As our mixed juice is limed alkaline to phenolphthalein, no extra lime is added to the mud.

Onomea Sugar Company: Presses dressed with double cloths, outside cloth unbleached factory cotton. The advantages are: mud leaves the cloths clean at each emptying, no muddy juice can get to the evaporators and less washing of inner cloths is necessary.

Presses filled by pump, relief valves set at 25 pounds, wash water from second cell of evaporator at 150° F. and 30 pounds pressure. Two presses filling at one time; starting one when other is half full. Washed in one and a half hours. About 2,500 gallons of water per press of 530 square feet area. Press discharges 2,500 pounds of mud. Wash water to below 1° brix.

Average sugar in mud to date .37 per cent. I do not believe the sugar can be washed from the mud with little water. We apply water freely immediately after juice is shut off and endeavor to wash out rapidly. Evaporators ample to handle washings.

The three reports given above are of particular value becuse they represent factories where press work is good. Onomea and Pepeekeo are among the five factories reporting less than 1 per cent polarization in the press cake for the 1923 crop. At Pioneer the polarization was 1.33, but the press station is rated at about 50 per cent of required capacity. A summary of these reports together with certain observations on press work made by the writer are as follows:

Presses must be tight. The water that leaks out between the frames and plates during washing contains very little sugar. This can amount to a surprisingly large quantity of water in some cases. It throws an additional load on the evaporators and adds to the length of time a press must be washed in order to bring the polarization down. In cases where it seems impossible to keep a press from excessive leaking during washing, double pressing has been suggested. Another method of handling excessive wash water leakage would be to separate the leakage from the wash water coming from the cocks and use the former for maceration at the mill.

Pressure during filling should not be greater than 25 pounds. Good press work is seldom accomplished when the pressure exceeds this figure, and a lower pressure frequently gives good results. A gravity head giving from 10 to 15 pounds pressure is a good arrangement. If this produces a soft cake that will channel too easily it can be corrected by heavier liming of the settlings. This cake will probably wash more easily than one made at a higher pressure and not limed so heavily.

Complete cycle of operation should not exceed six hours. Under average manufacturing conditions, where the time is longer than this, inversion is very apt to take place giving a low polarization of the mud and a higher undetermined loss. To guard against inversion the temperature should not fall below 165° F. and the alkalinity not below 7.7 to 8.0 pH.

The quantity of water in washing presses can be reduced by washing with fresh water during the last third of the washing cycle; this flows to a tank from where it can be pumped back through a press during the first two-thirds of the washing cycle.

Low Grade Work

Onomea Sugar Company: Essentials are, ample pan, crystallizers and centrifugal capacities. Good even grain. Struck at 97.0 to 98.0 brix. Moved in crystallizers from 8 to 10 days. Cured without diluting to avoid dissolving sugar, as every per cent dilution of massecuite, the resultant molasses will be increased about one per cent in purity.

This year on account of lack of low grade centrifugal capacity, caused by larger cane tonnage, we have been forced to dilute second massecuite 3 or 4 per cent more than formerly with the corresponding rise in waste molasses purities.

McBryde Sugar Company: Under our conditions, we believe in having a purity of 54-55 and brix of 98-99 for our low grade; also in adding enough water, under close supervision, in the crystallizers to give a brix of 96-97 for drying.

The purity of the final molasses is determined by the brix and purity of the massecuite at time of dropping, skill in pan work, time of boiling, careful crystallizer work and brix of massecuite at time of drying. Any dilutant or heat will raise the purity of the molasses other than molasses or water in crystallizers when skilled attention is given to it.

The purity of the low grade sugar is determined by the purity of the massecuite, quality and size of the grain and brix at drying.

The factors affecting the drying of low grade massecuite, we believe are: size and quality of the grain, brix, purity and temperature of the massecuite when drying and good clarification. Consistent work at the pans is essential for good drying sugar; any attempt to speed up a sugar that is slow drying, due to poor boiling, only results in an increase in the final molasses purity. The brix and purity of the massecuite have to be determined by the available centrifugal capacity, but the massecuite should be as near 70° F., at the time of drying, as possible. Fine suspended matter slows up drying to a marked extent; since the installation of a Peck strainer here, we have noted a great deal of improvement in this respect.

Hawaiian Sugar Company: There is great trouble in getting uniform grain or crystal; the opinions of sugar makers differ as to which is the right way of getting low molasses purity. Many changes are taking place in boiling to finish and we have had very good results here with a purity of molasses of 52 to 54. A higher purity does not answer as well as a 54 purity in boiling even grain. Most of the trouble comes from variety of canes and situation of fields; all troubles are local.

Pepeekeo Sugar Company: The two principal controlling factors of the gravity purity of the final molasses are, the skill in low grade boiling and the glucose content. If a good purity drop in the low grade pan is secured the final molasses will be low, providing the dilution of the massecuite is not more than 95 degrees brix before drying. The average drop at Pepeekeo in the low grade pan is 20 points, which gives a hot molasses of 33 apparent purity. We find that under the same conditions, a molasses of higher glucose content will produce a lower gravity purity than one of a lower content.

At Pepeekeo the purity of low grade sugar and its ease of drying depends on four factors, namely, purity of massecuite, size of grain, clarification and the presence or absence of false grain. A massecuite of 54 purity will dry much better than one of 50 purity and still give a low molasses with a higher purity sugar. A large grain dries better and with proper boiling a good drop can be obtained. Good clarification gives a freer drying massecuite, one that is not too sticky. It is my opinion that the presence of false grain is the main factor in drying of the low grade.

Pioneer Mill Company: In my opinion the factors necessary to reduce the purity of the waste molasses, in order of their importance, are:

1. That the massecuite should be boiled as stiff as it is possible to handle subsequently.

2. That it should be free from grain .1 mm. or less.

3. That the grain should be even and of average size (.3 to .4 mm.).

In low grade massecuite there are two results to be desired: low molasses and higher sugar. While the low grade equipment available is usually the deciding factor on the method of procedure to obtain these results, there are certain other influencing factors the importance of which has not been agreed upon.

The brix purity of the massecuite, and the days in the crystallizers are some of the factors which decidedly influence the purity of the final molasses. Just how much they influence the purity, within certain limits, is difficult to state. A consideration of the analysis of a small number of strikes is apt to be misleading, but if a large number are under consideration, general conclusions might be attempted.

The following figures have been compiled from the laboratory records of the past four years at the Lihue factory to see if such data can throw any light on the subject in question. Over 1,000 strikes are included, representing the analysis of more than 400 samples:

	Massecuite		Molasses		Days in
	Brix	Purity	Brix	Purity	Crystallizers
1921	98.1	51.5	91.7	31.4	11
1922	98.7	52.7	92.6	31.4	13
1923	97.5	51.4	93.6	29.3	11
1924	97.0	53.4	92.8	29.4	12

During 1921 and 1922 the only thing that limited the brix of the massecuite at striking was the difficulty in getting it out of the pan and into the crystallizers. Individual strikes were frequently over 100 brix; time required for discharging the pan was between one and two hours. After about four days in the crystallizers water was added each day until the massecuite was sent to the mixers.

The brix at the time of striking was considerably reduced during the 1923 and 1924 crops. Certain operations in low grade work were facilitated by this change and the final molasses was not higher than it was previously. That it was actually lower is, of course, not attributed to the lower brix but for other reasons that will be discussed later.

From these figures it seems fair to assume that nothing is gained by boiling low grade massecuite to a higher density than it can be handled in the centrifugals. However, the usual factory practice is to boil to a slightly higher brix than can be dried, and water is afterwards added in the crystallizers or a mingler. This is done as a precautionary measure to avoid the possibility of striking at too low a brix, and because if any unforeseen event permits longer time in drying, the benefit of a higher brix will be obtained.

In regard to the final molasses in 1923 and 1924, which was lower than in the two previous years in spite of a lower striking brix, your attention is directed to the figures for 1921 and 1923. During these two years the massecuite stayed in the crystallizers the same number of days, the massecuite purities were practically the same but the purity of the final molasses was lower in the later year. The reason for this is very apparent in the brixes of the molasses, which should be an indication of the drying brix of the massecuite since there was no dilution of the molasses before sampling. That the drying density of the massecuite is

one of the deciding factors on the purity of the final molasses is a fact too well established to need discussion here.

A further study of the Lihue figures in hopes of determining the effect of the massecuite purity on molasses purity seems futile. The figures for 1924 in particular upset preconceived ideas on the subject. One would naturally expect the purity of the molasses to increase as the purity of the massecuite increases, but it did not do so here, even in spite of a lower drying density. A comparison of the four years is quite like comparing one strike with another. It is only necessary to look at the low grade massecuite records of the average factory to see massecuites of the same density, but differing in purity by several points, yet yielding the same final molasses. This leads one to the conclusion that there are other factors of even more importance than the purity of the massecuite that determine the purity of the final molasses.

The following tabulation for the 1924 crop was made in order to see if any effect on the purity of the molasses could be accounted for by the number of days the massecuite stayed in the crystallizers:

Days in Crystallizers	Massecuite Brix	Massecuite Purity	Molasses Brix	Molasses Purity
Under 10	97.0	53.3	93.0	29.3
11 to 15	96.9	53.4	92.5	29.4
Over 15	97.4	53.3	93.6	29.4

As far as the purity of the final molasses is concerned, apparently no advantage is gained in the crystallizers after ten days. Reports based on laboratory separation of the sugar and molasses have shown that there is a continued drop after ten days, but it is so small per unit of time in comparison with the first ten days that in order to get the advantage of it the crystallizer capacity would have to be increased beyond what is practical in manufacture.

The purity of the low grade sugar depends on how completely a separation of the sugar and molasses is accomplished in the centrifugals. In other words, the purity of the remelt depends on the drying qualities of the massecuite. Speaking in terms of *actual factory operations,* what is usually meant when a strike is considered "good" is that it can be dried and the better it dries the higher the melt.

It is now generally agreed upon that grain less than .1 mm. long is one of the chief causes of difficulties in drying low grades. Opinions differ as to whether irregular grain longer than .1 mm. can cause poor drying, but as a rule an even grain seems to be desired. If "even" grain is intended to mean that all grain is of the same length then the writer does not believe that, as far as grain is concerned, an even grain is essential. Strikes containing grain all of .2 mm. in length will not dry as easily as strikes of irregular grain ranging from .2 mm. upward; the range being limited to that length which is usually found in low grade strikes.

There is no doubt that the grain is a contributing factor to the drying qualities of low grade, but, it is not the only factor; otherwise, the difficulties in drying could be overcome in the pan work. Rather than blame the drying on the grain it seems possible that the grain might be an indication of either of two things or of them both. First, it might indicate the presence of constituents in the

molasses which are causing the trouble. Second, the grain might indicate how successfully the pan work has been done in spite of these constituents.

Obviously, entirely too much poor work in sugar factories is blamed on the juice or the cane or various other causes, but it seems evident that the juice on different plantations does work differently. A. Fries reported to this Association in 1920 that he noticed a very marked difference in results between Lahaina and Makaweli. He said:

> In respect to the crystallizer strikes, I have noticed a very important difference in the massecuite here at Makaweli and that at Lahaina. Although boiled under the same conditions and of syrup of similar purity, the massecuite is, on the whole, far freer and less viscous than that at Lahaina. We are able to purge the low grades in less time, getting a higher purity melt and a final molasses from two to three points lower in purity. Others have observed that while it is possible to do very good work in one factory, the same sugar boiler will find it impossible to get equal results at some other factory, though the equipment and conditions are alike. This is due to the peculiar quality of the juices. Probably the nature of the impurities if better understood would give a more satisfactory explanation.

The writer has had a similar experience in comparing Lihue with several other places, but particularly with Lahaina. On my arrival at Lihue certain changes were made in the boiling house to accommodate the accumulation of low grade sugar that would result from Sunday drying, it being anticipated that this sugar would be loaded with molasses and could be best kept on a concrete floor with retaining walls to keep it from spreading. The results were quite to the contrary. The low grade dried so thoroughly that it could be kept in bags without much discoloration of the bags. After certain changes in methods were inaugurated to conform with usual practices the purity of the final molasses was very much reduced. Evidently some constituents or qualities of the juice are responsible for the ease with which the low grades work.

Pan men attribute difficulties in boiling low grade to the molasses being "sticky." The same reason is given for difficulties in drying, when the grain is not at fault. The effect of viscosity may not be noticeable on plantations where conditions regarding elevation, variety, time elapsing between harvesting and grinding and other conditions are fairly constant, but, on plantations where extremes are met, difference in viscosity and resultant difficulties in low grade work are noted.

High viscosity is particularly noticeable in molasses from cane that is ground a long time after burning, as might result from an accidental cane fire. It differs with different varieties, elevations and soil conditions. It is not dependent on purity, meaning that a cane giving a high purity juice will not necessarily give a molasses of low viscosity and a 50 purity molasses is not always more viscous than a 55 purity. As far as Lihue is concerned, viscosity and its resulting difficulties in working low grades does not depend on clarification. Here the turbidity of the clarified juice on 3-hour composite samples for the last three months of the year averaged 1.7 cm. and yet the low grades work easily and the results are satisfactory.

Reference has been made to the literature on sugar that is accessible to the writer on the subject of viscosity. Geerligs says: "It is therefore desirable from a manufacturer's point of view that the molasses be as little viscous as possible in order to enable it to be easily separated from the crystals without much washing in the centrifugals."

Deerr: ". . . . . accordingly viscosity can only be of influence in determining the time taken for complete crystallization. Technically this influence is not unimportant, and is particularly noticeable in the comparison of the rapidity of crystallization in refineries and in raw sugar houses, material of equal purities (but without the 'gums' removed by char filtration) crystallizing much more rapidly in the refinery than in the raw sugar house."

Claassen: "The viscosity of syrups or molasses is decidedy a hindrance to rapid graining."

It is observed that these writers agree that viscosity has an objectionable effect on boiling and drying. The causes of viscosity are thoroughly discussed by Geerligs, but they are irrelevant at this time, it being more to the point to initiate a study of effects based on actual viscosity determinations. To date it has seemed impossible to get a means of successfully measuring the viscosity of undiluted high density sugar house products. The writer attempted this a few years ago by means of timing the fall of a steel ball through a column of molasses. Concordant results could not be obtained. It is understood that the H. S. P. A. Experiment Station has now developed a viscosimeter. When the viscosity of the molasses is accurately determined it is highly probable that it will give considerable light on difficulties encountered in low grade work.

In the consideration of low grade the writer feels that it resolves itself into the understanding of certain fundamental facts, the application of which is limited by equipment available under manufacturing conditions.

In order to extract the sugar that is in the molasses, crystallization is resorted to. The greater the surface of the crystals exposed to the sugar solution the greater will be the opportunity for the sugar to crystallize out of solution. The smaller the crystals per given weight the greater will be the surface, but as the size of the crystals decreases the difficulties in drying increase. Hence the limiting factor here is the centrifugal capacity.

The lower the water content of the massecuite the more sugar has crystallized out. Crystallization increases with density, but the difficulties in drying also increase with density, making the centrifugal again the limiting factor.

The lower the purity of the material in the pan the greater will be the difficulty in getting grain and making it grow. The longer the time for this operation the greater will be the opportunity of getting the desired results. Consequently, the limiting factors here are purity, pan capacity and skill.

Crystallization in the pan is accomplished by the reduction of water, and in the crystallizers by the reduction of temperature. It would then seem that when all other conditions remain the same, the amount of crystallization that can take place in the crystallizer is limited, but it is not limited in the pan.

The purity of the remelt indicates how completely the drying has been accomplished and how much of the waste molasses is taken back into process. The

available centrifugal capacity determined this and the practical limit to the molasses taken back will depend on the capacity for handling both low and high grade products.

The non-sugars present in low grades add to the difficulties in crystallization and separation. It is possible that their effect can be measured in terms of viscosity. Investigation along this line should be inaugurated.

Commercial Sugar Boiling

Letters sent out requesting data to come under this head asked for information relative to the advantages or disadvantages of the Pioneer system of sugar boiling in comparison with other systems. The impression conveyed by the replies is that the number of factories that are changing over to the Pioneer system is increasing and satisfactory results are following.

The demand for a high polarizing sugar is one of the reasons for the increasing popularity of the Pioneer system. It is doubtful if any factory attempts to get a high commercial sugar and a molasses low enough for low grade by maintaining all the high strikes at a fixed purity. Those not using the Pioneer system evidently do boil commercial sugar strikes of different purities, but not by returning all or none of the molasses as is usually done in the Pioneer system.

This brings up the fact that there is one variation to this system that sometimes comes up for discussion. The Pioneer system can be briefly described as the system of taking back *all* of the molasses from the preceding strike until the molasses has reached a purity low enough for the crystallizer strikes. Starting with a syrup purity of 84, the B molasses will be between 50 and 55. If 55 has been set as the arbitrary limit for crystallizer strikes what should be done if the B molasses is 56? If all of the B molasses is taken back into a C strike, the resulting massecuite will be below 70; if only half is taken back the C massecuite will have a purity higher than the B massecuite. An answer to the question depends to a great extent on capacities. If there is ample pan and centrifugal capacity a C strike should be made. Where these capacities are limited and there are enough molasses tanks to reserve some exclusively for B molasses, it will be easier to boil the C strike to a fixed purity, using only a part of the B molasses, necessitating that the remainder be held over for some future strike.

However, it must be remembered that if the latter procedure is followed it introduces certain complications into the control of the boiling, which the Pioneer system aims to avoid. The simplicity of control in a boiling system should not be underestimated, particularly in a factory lacking in adequate supervision, as may be the case in smaller factories during the night shift. With the Pioneer system, a brief examination of the pan records or an inspection of the pan floor will immediately tell if the boiling instructions have been and are being correctly carried out. This is but one of the advantages in strictly adhering to the Pioneer method. Where capacities permit, all or none of the molasses should be returned to the high grade strikes.

Hutchinson Sugar Plantation Company: We have been using the Pioneer system here for the last 14 weeks and find it a great improvement over our old method of returning molasses to all our No. 1 strikes without any given definite system or routine. The enclosed table of averages purities and polarization will give the best information available. We certainly shall continue using the Pioneer system here in the future:

	A			B			C		
	MC.	Mol.	Sug.	MC.	Mol.	Sug.	MC.	Mol.	Sug.
May	80.4	61.8	97.6	75.9	56.7	97.1	73.1	54.1	96.9
June	83.3	64.2	97.9	77.5	57.7	97.0	72.9	53.6	96.8
July	79.3	60.1	97.5	76.0	56.1	97.3	72.2	53.6	97.1

Onomea Sugar Company: We changed to the Pioneer system at the beginning of 1921. Previously we endeavored to make uniform strikes of 78 to 80 purity, giving sugar of 96.0 to 96.5, polarization and molasses of 50 to 55 purity, starting every week with fresh molasses. This meant extensive reboiling of molasses. The demand of the refineries for a higher polarizing sugar than we were then able to make and the desire to keep our molasses purity down, caused us to adopt the above method, which is still in use at this factory.

Some of the advantages are, a higher polarizing sugar without increasing the purity of the molasses for crystallizer strikes, no repeated boiling of molasses and only one strike of molasses on hand at one time.

Average to date:

	Massecuite Purity	Molasses Purity	Sugar Pol.
A	85.5	67.1	98.42
B	78.5	57.1	97.08
C	75.0	52.0	96.63
Average polarization to date of all strikes			97.48

McBryde Sugar Company: We believe the Pioneer system of sugar boiling to be a very satisfactory method on account of its flexibility and systematic elimination of molasses, resulting in a better color and filtrability of No. 1 sugar and easier working low grade. The drop in purity from massecuite to molasses in our high grade strikes is from 20 to 24 points.

Hamakua Mill Company: I use the one-six method, that is, one straight syrup strike to five mixed strikes. Below is a tabulation of one week's pan work consisting of 39 strikes of commercial sugar, 6½ cycles of 6 strikes each, average purity 76.60, molasses purity 53.58. Out of these 6 cycles, I boiled 9 No. 2 strikes averaging 49.45 purity.

	Purity Massecuite	Purity Molasses	Points Drop
A	86.78	68.77	18.01
B	78.35	54.27	24.08
C	76.85	50.38	26.47
D	74.58	50.15	24.43
E	74.12	49.98	24.14
F	73.18	49.53	23.65

I know of no reason why we should have a large drop this year over last year except for the Petree Process. We have a cleaner syrup, otherwise our juices have been practically the same. The massecuite is dried hot.

Waimanalo Sugar Company: In using the Pioneer system I boil a D strike if the C molasses is over 54 purity, otherwise the C molasses is boiled for crystallizers.

Average for two weeks:

	Sugar Polarization	Massecuite Purity	Molasses Purity	No. of Strikes
A				
Range	97.1–98.4	82.2–86.5	61.5–68.5	9
Average	97.7	84.0	64.8	
B				
Range	96.5–97.2	73.2–78.3	50.8–57.4	9
Average	96.7	75.0	53.8	
C				
Range	96.6–96.7	72.7–74.9	51.3–54.6	4
Average	96.1	74.0	53.0	
D				
Average	95.2	73.3	50.0	1

Hawaiian Sugar Company: The boiling at the Hawaiian Sugar Company's factory consists usually of four strikes of about 38 tons of sugar per strike. The procedure we follow is to start a strike of 3 tons of seed of about 82 purity and after the pan is filled up with syrup to cut half over into another pan. The strike is completed with syrup of 87 purity and gives a 97.5 sugar with .5 per cent moisture and 72 purity molasses. The next strike is made from the other half of the cut and the molasses from the first strike. This will give a 97 sugar with .6 per cent moisture and a molasses between 62 and 64 purity.

The seed pan is again started up in the manner previously described and the first cut is finished with the molasses from the second strike. The resulting molasses is 58 purity and the sugar 97.0 polarization. The other half of the cut is finished with 58 molasses and gives a 96.8 sugar and a molasses of between 52 and 54 purity. This molasses is boiled for crystallizer strikes.

Pepeekeo Sugar Company: We are making a 97.5 polarization sugar by boiling a straight syrup strike every third pan. This massecuite has an 86 purity, giving a 98.3 sugar and 60 to 62 purity molasses. This is all returned, resulting in a massecuite of 77 purity, a sugar of 97 polarization and a molasses of 51 to 54 purity, of which a part is used in the third strike which gives a massecuite of 75, a 97.3 sugar and a molasses of 50 to 52 purity, all of which is used in boiling the low grade. As high a polarization sugar is made as the capacity of the low grade pan and machines will permit, without excessive sucrose loss in the final molasses.

Pioneer Mill Company: The Pioneer system has been used here for many years. Its chief advantages are in its flexibility and in the "cleaning the house" of molasses every third strike. Its chief disadvantages are that it requires three sets of molasses tanks, each holding the molasses from one strike or more, and that the mixer be completely emptied between strikes. Neither of these, however, will apply here, as we have eight molasses storage tanks on the pan floor and three more on the ground floor and our mixer is too small to hold more than one strike. We have storage capacity for 1,184 cubic feet of "A," 1,239 cubic feet of "B," 1,421 cubic feet of "C" molasses, besides 410 cubic feet below the centrifugals. In 1923, the molasses from the different grades averaged 35 tons for "A," 38 tons for "B" and 40 tons for "C."

The flexibility of this system was very evident this season when we desired to raise the polarization of our shipping sugar. Last crop, our sugar polarized 97.37 at the refinery. So far we have received returns on 26,000 tons which have polarized 98.22 at the refinery (including sweepings, etc.). This gain of .85 was very simply accomplished by using a little more water at the centrifugals. The effect of this on the method of boiling was as follows: The amount of seed was reduced by one-third to counteract the effect of the wash water and to reduce the "total small" grain. The drop in purity from massecuite to molasses was reduced by 1 per cent, which increased the number of "C" strikes. In 1923, we boiled 68.56 "C" strikes per 100 "B" strikes, while in 1924 there were

89.54 "C" per 100 "B" strikes. Part of this increase, however, was due to the higher syrup purity, with the consequently higher purity of the "A" strikes and to the manufacture of considerably more "store sugar." The average time of drying all three grades of sugar was reduced by almost half an hour. The following tables show the apparent purity (dry lead method) of the massecuite and molasses, the percentage of the three grades and the composition of the strikes. Strikes of store sugar are included with the "A" strikes:

	Syrup	Massecuite				Molasses			
	Purity	A	B	C	D	A	B	C	D
1922	85.49	84.3	76.9	73.9	73.5	65.9	58.4	55.6	55.3
1923	86.16	85.2	77.2	74.4	70.6	65.3	56.1	53.4	50.5
1924	86.87	85.76	78.7	74.4	....	67.4	58.4	54.6	....

	Number of Strikes				Per Cent			
	A	B	C	D	A	B	C	D
1923	336	334	229	1	37.3	37.1	25.5	0.1
1924	393	392	351	0	34.6	34.5	30.9	0.0

AVERAGE COMPOSITION OF STRIKES

("Tons" by measurement)

	1923					1924				
	Syrup	Remelt	Molas.	Seed.	Mass.	Syrup	Remelt	Molas.	Seed.	Mass.
First cut	47.2	....	....	6.56	....	48.0	....	....	4.33	....
Second cut	6.5	....	....	....	21.8	7.1	....	....	....	21.4
"A"	50.7	11.4	....	....	23.9	47.9	13.3	....	....	24.3
"B"	16.6	4.2	34.9	....	23.6	19.9	3.8	35.2	....	23.8
"C"	15.6	4.4	34.4	....	23.9	19.9	4.1	35.8	....	23.7

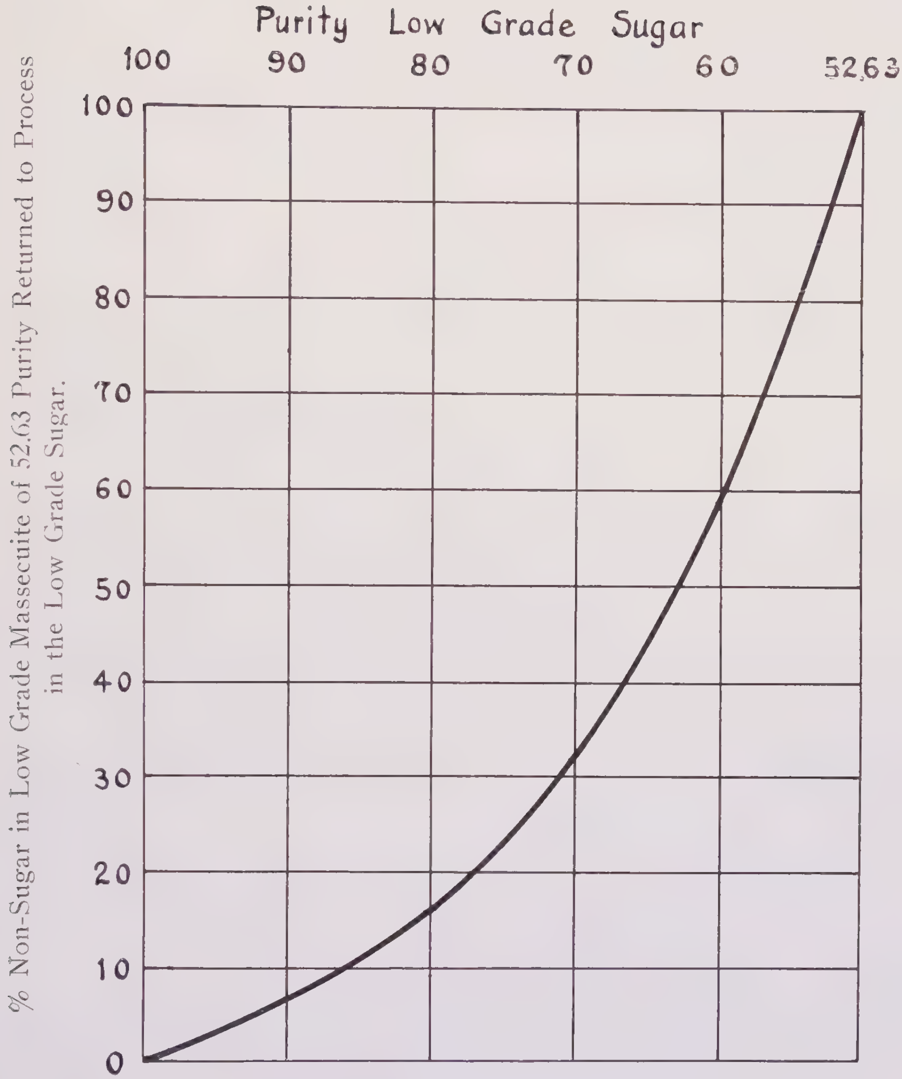
	Per cent Strikes Containing Remelt			Average Cu. Ft. Remelt Used		
	A	B	C	A	B	C
1923	84.36	72.24	70.22	12.14	5.77	6.25
1924	95.40	77.81	82.39	13.96	4.84	4.94

Miscellaneous

Double Purging: One of the aims in the recent changes in boiling in the Islands is to limit reboiling. With the Pioneer system the only possibility of extensive reboiling is the return to the process of molasses with the low grade sugar. Any other product that is returned, is a *solution* of sugar, but in the case of low grade sugar it is a *mixture* of sugar crystals and waste molasses.

In order to calculate the quantity of material that is returned, a low grade massecuite of 52.63 purity was assumed to be a mixture of 25.25 parts of sugar crystals of 100 per cent sucrose and 74.75 parts of waste molasses of 35.48 gravity purity. It will be noted in the accompanying graph that the quantity of waste molasses returned to the process is approximately inversely proportional to the purity of the low grade sugar.

An 80 purity low grade sugar is probably above the average of low grade purities reported this year, and yet it means that 16 per cent of the *waste molasses* is returned to the commercial sugar strikes. When the purity is 70, the molasses



returned is 32 per cent, which, in the case of Lihue, would be equivalent to saying that every fifth crystallizer strike is due to returned waste molasses.

Walter E. Smith, in his work on the filtrability of raw sugar, concludes that filtration difficulties are due principally to finely divided non-settling matter. On a special investigation trip to Kauai he found that Lihue was making a raw sugar of high filtration rate from syrup of low filtration rate. This was contrary to what he had found at other factories and he attributes this condition at Lihue to be due to the comparatively low quantity of waste molasses that is returned to the process with the low grade sugar. This is compatible with his former findings that low filtrability is due to non-settling matter and as he points out the "molasses represents the greatest concentration of this non-settling matter."

At the suggestion of Mr. Smith some of the factories have started double purging of the low grades in order to get a higher remelt. The scheme consists of making a magma of low grade sugar with water. This magma is then dried, giving a remelt considerably higher than the original low grade sugar and a molasses that is about the right purity to be boiled for crystallizer strike. It is to be noted that the waste molasses is kept out of the commercial sugar strikes, which should attribute to a higher filtration rate of the raw sugar, but it is returned to the crystallizer strikes as formerly.

The writer has not been able to get much data covering actual results of double purging or information on the changes and extra equipment necessary. Toward the end of the present crop Waimanalo double purged the low grade and it is understood that from a low grade magma of 72 to 75 purity they were able to obtain a double purged sugar of from 85 to 87 purity and a run of between 48 and 50 purity. Later the magma was reduced to 68 to 73 purity, which on the second purging gave an 86 to 90 purity low grade sugar and a run of between 46 and 50 purity.

Liming: Equipment that will permit an easy means of keeping the limed juice at a uniform reaction is the exception rather than the rule in our sugar factories. The most common arrangement is to dump the raw juice from the scales into a large receiving tank where milk of lime is added at the same time as the juice. Mechanical stirrers of compressed air are used to attempt a good mixture, the reaction being regulated by testing the limed juice from a sample pipe that is tapped into the pipe line leading to the heaters.

The arrangement is usually not satisfactory. It is difficult to get a good mixture of a few buckets of lime milk with one to two thousand gallons of juice, especially when the limed juice is constantly being drawn off. The Waipahu liming device has expedited the problem by introducing a constant small stream of milk of lime into the raw juice just before it enters the limed juice pump. The Makee Sugar Company handles it in a satisfactory manner by weighing on a small scale enough slaked lime for one scale tank of juice. Water is added to this lime to make a milk which is put into the scale tank before the juice is turned in. Compressed air blown up in the receiving tank under the scales further assures a good mixture.

Both of these methods give good results when only mill juice goes into the receiving tank, but when the press juice has a different reaction to the clarified juice it must also go into the receiving tank. Under actual working conditions this means that just before a scale tank is dumped the juice that is being drawn from the receiving tank is press juice, resulting in an uneven reaction of the juice going to the heaters. The writer understands that at Wailuku a small tank to hold the press juice has been installed alongside of the juice scales. The press juice is allowed to accumulate in this tank and it is emptied into the receiving tank when every scale tank is dumped.

Lihue has solved the problem by welding a small cylindrical tank to the pipe that leads from the receiving tank to the intake of the juice pump. The tank is made from a section of a 10-inch pipe and is open at the top. The press juice is pumped into the tank and joins with the limed juice at a constant rate.

This has made it possible to carry a more uniform reaction in the limed juice. The writer believes that where there is sufficient gravity head from the presses to this pump the tank can be dispensed with. All that will be necessary will be a pipe line from the presses joining the limed juice line near the intake of the juice pump.

In conclusion, the writer wishes to acknowledge the receipt of data relative to this report from G. F. Murray, Hamakua Mill Company; J. H. Pratt, Pioneer Mill Company; Wm. Schneider, Waimanalo Sugar Company; A. B. Melancon, McBryde Sugar Company, Limited; H. D. Beveridge, Onomea Sugar Company; F. D. Bolte, Hutchinson Sugar Plantation Company; Wm. Ebeling, Hawaiian Sugar Company; Norman King, Koloa Sugar Company, and the Sugar Technologists of the H. S. P. A. Experiment Station.

Centrifugal Pumps*

By Wm. H. Getz

Rotary or wheel pumps are among the earliest types of pumping machinery known. They were operated by hand or by slow moving animals, or perhaps, by the current of a stream or river and, consequently, their speed of rotation was very low. No attempt, therefore, could be made to utilize the centrifugal effect of this rotation and in the primitive forms they served merely as lifting devices for buckets or troughs, the elevation to which the water could be raised being limited by the height of the wheel. These earlier forms cannot, therefore, be classified as centrifugal pumps, although they possibly suggested the use of this type.

On first acquaintance a centrifugal pump seems to be rather erratic in its performance. It does not appear to follow any particular laws, and in many cases its action is exactly contrary to the well known laws governing other types of pumps. Size and capacity seem only remotely related. A 10″ pump may deliver two million gallons or six million, or we may find small pumps with capacities much greater than big ones.

In cases where a definite amount of water is to be pumped, we note that the higher the head the smaller the pump required. Also, we find that when we lower the head on a centrifugal pump in operation, we increase the power needed to drive it. Then again, there seems to be little, if any, connection between the size of the pump and the size of the suction and discharge piping.

Paradoxical as these facts seem to be, they are, however, easily understood when we know the laws governing this type of pump which are just as definite as those relating to any other type of machinery. The centrifugal pump is a machine which depends primarily for its operation on the development of velocity.

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* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

It is governed by two simple laws—first, that the head varies as the square of the speed, and second, that the capacity varies directly as the speed. The velocity of the water leaving an impeller is approximately the same as the velocity of the rim of the impeller, and must be about eight times the square root of the head pumped against, or about equal to the velocity that water would attain in falling from the height to which it is being raised.

Theoretically, a centrifugal pump imparts a sufficiently high velocity to a liquid to carry it to the necessary height. In reality, a transformation from velocity to pressure takes place in the pump so that the liquid in leaving has a velocity only sufficient to carry the desired quantity of water through the discharge line. Should the discharge valve be closed, all the velocity will be converted into pressure.

The peripheral velocity of the impeller of a centrifugal pump has, therefore, a very definite relation to the head against which the pump must operate. High heads or pressures of necessity mean high peripheral speeds in order that the velocity attained by the water in the pump may be sufficient to produce the necessary kinetic and pressure heads. High peripheral velocity can be produced either by a large diameter runner operating at slow speed or a small impeller operating at high speed.

Previous to the development of the steam turbine, centrifugal pumps for high head were almost necessarily motor driven, as the only prime mover available for driving them was the slow speed steam engine, which required impellers of such large diameter that they were difficult to manufacture, especially for small capacities. Large sizes also greatly increased the weight, thus tending to offset two of the big advantages of this type, namely, low cost and small space occupied. With the introduction of the steam turbine, operated at extremely high speeds the problem of direct connection to centrifugal pumps was reversed, it being now necessary, except for very high heads, to use reducing gears to bring the speed within the limits of pump design. The lower limits for the diameter of a centrifugal pump impeller are fixed by the fact that it must be enough larger than the suction inlet or eye to provide the necessary space for the vanes.

A very large percentage of the centrifugal pumps which are installed is motor-driven, and fortunately, the range of speeds obtainable is very well suited to most conditions. However, since no economical method of speed variation is available, it is desirable that the pump specifications be as near to the actual operating conditions as possible.

Although a centrifugal pump once built and installed has only small flexibility unless speed variations are possible, there is, however, quite a little latitude in design possible, so that the pump may be adapted to take unavoidable fluctuations to the best advantage.

Varying the blade angles of the impeller causes a considerable change in the characteristic curves. The most advanced builders provide as many as four distinct types of runner, from which the one best suited to conditions in each case may be selected. We are giving three charts illustrating this feature. In each case the pump is designed for the same normal conditions, namely, 2,000 g. p. m. against 70-foot head.

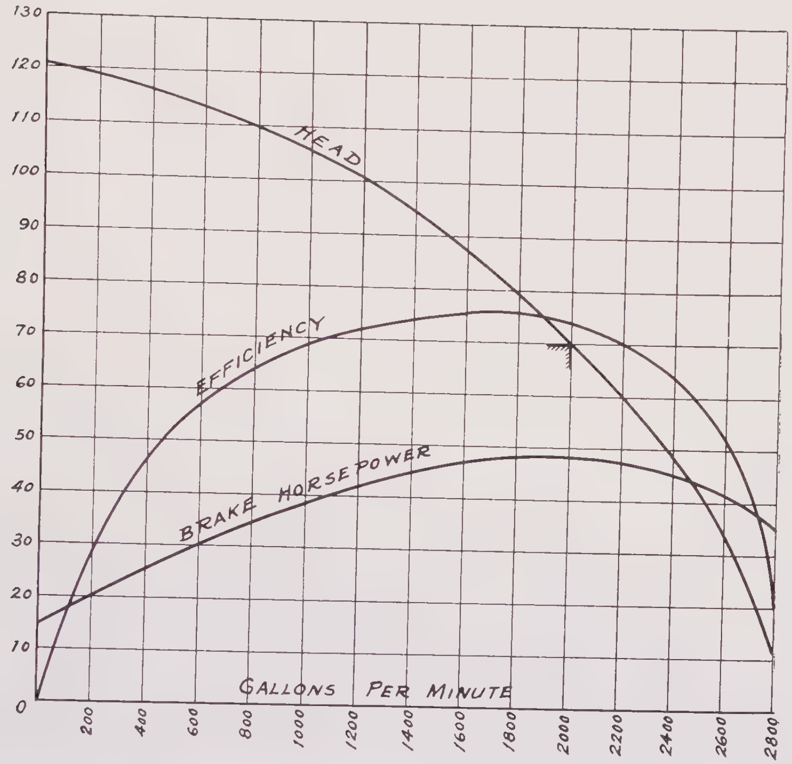
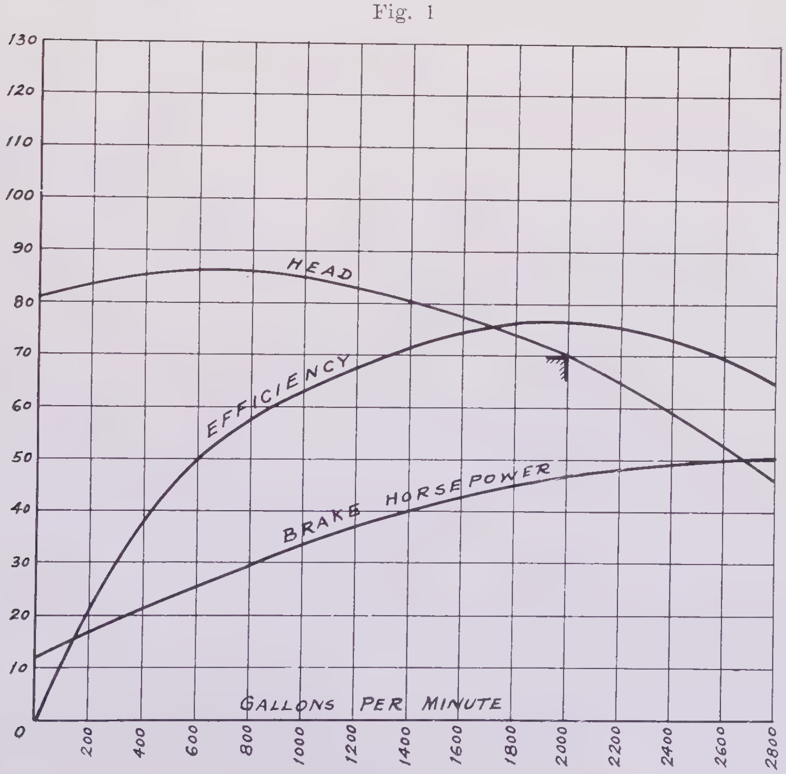

130
120
110
100
90
80
70
60
50
40
30
20
10
0
HEAD
EFFICIENCY
BRAKE HORSEPOWER
GALLONS PER MINUTE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800

Fig. 1


130
120
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90
80
70
60
50
40
30
20
10
0
HEAD
EFFICIENCY
BRAKE HORSEPOWER
GALLONS PER MINUTE
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800

Fig. 2

Fig. 1 shows a pump having a very steep head-capacity curve. Large changes in head produce relatively small changes in capacity. This type would be suitable for use with a barometric condenser where the head is greatly reduced after the vacuum has been produced. The horse power curve is of the falling type, being a maximum under normal conditions.

Fig. 2 shows a pump having a very flat characteristic curve. This pump would be well adapted to maintaining a nearly constant pressure in a city's water mains, when the demand varies greatly. The low shut-off pressure would also serve as a protection against high pressures in the pipes at very low capacities. The horse power curve in this case is of the rising type. It is evident that had the normal rating of this pump been, say, 1,400 gallons per minute against 80-foot head, the maximum horse power required would be more than 25 per cent above that required for rated conditions.

For ordinary uses runners are usually furnished with characteristics between the extremes shown above, as illustrated in Fig. 3.

Since it is evident that the design of the impeller affects the horse power required under other than normal conditions, the motor furnished with a pump should in all cases be large enough to care for any possible conditions of operation. For this reason a falling horse power curve is desirable to limit the excess motor horse power required to take care of these unusual conditions. The best form of horse power curve is one which is a maximum for normal conditions and falls for either higher or lower heads. A centrifugal pump usually requires 40 per cent or less of normal power when the capacity is zero, and for this reason it is advisable to start the pump with the discharge valve closed. When this is not practicable, large motors should be of the wound rotor type.

As an illustration of the thoroughness with which some manufacturers have studied their product to permit of predicting with great accuracy the performance of a pump prior to its actual test, we are reproducing in Fig. 4 a so-called oak tree curve, showing the characteristics of a 10″ type "S" pump running at 1,160 r. p. m. These curves are made from actual tests as follows: The pump is first fitted with a maximum sized runner, in this case 17¼″ diameter, and a series of tests is run at different heads, giving the data for the upper curve. For each test, the efficiency is noted on the curve. The runner is now turned down to a somewhat smaller diameter and new tests run giving the data for the next curve. This is continued until the runner has been reduced to a minimum size. Points of equal efficiency in the different test curves are now connected giving the peculiar appearance from which these curves derive their name. This operation must then be repeated to obtain similar curves for all other standard speeds.

Practically, these curves are of value as follows: Suppose it is desired to know the performance of this particular pump for a capacity of 3,000 gallons per minute against a head of 90 feet. Taking the intersection of these two values, we find that the efficiency would be at least 80 per cent. A curve drawn through this intersection parallel to the adjacent curves, gives the characteristic "head-capacity" curve for the pump. Using the efficiencies shown for a number of points will give the Brake Horsepower curve, and we now have complete characteristic curves for this pump when designed for the normal conditions assumed

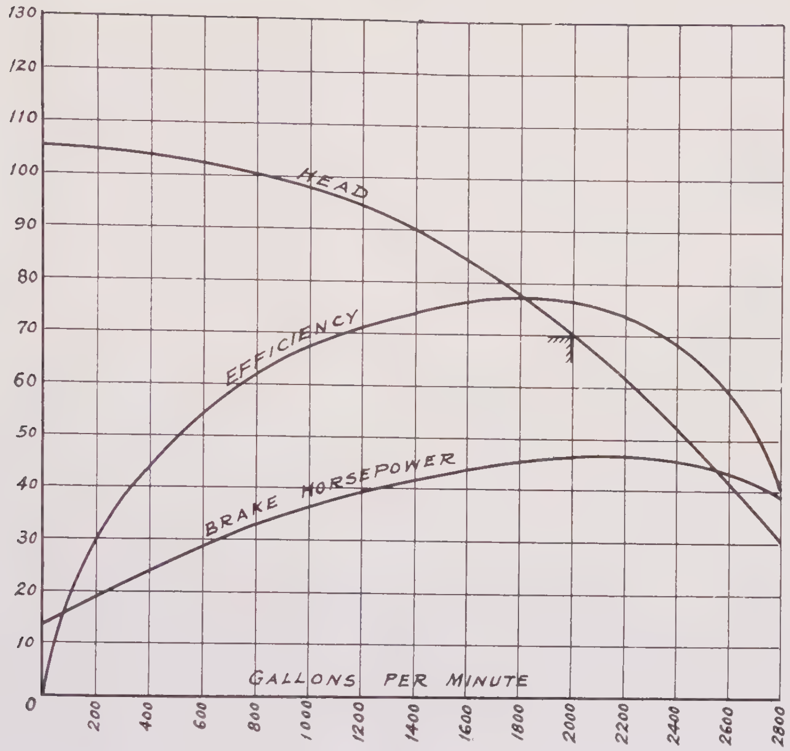
HEAD
EFFICIENCY
BRAKE HORSEPOWER
GALLONS PER MINUTE
0
10
20
30
40
50
60
70
80
90
100
110
120
130
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800

Fig. 3

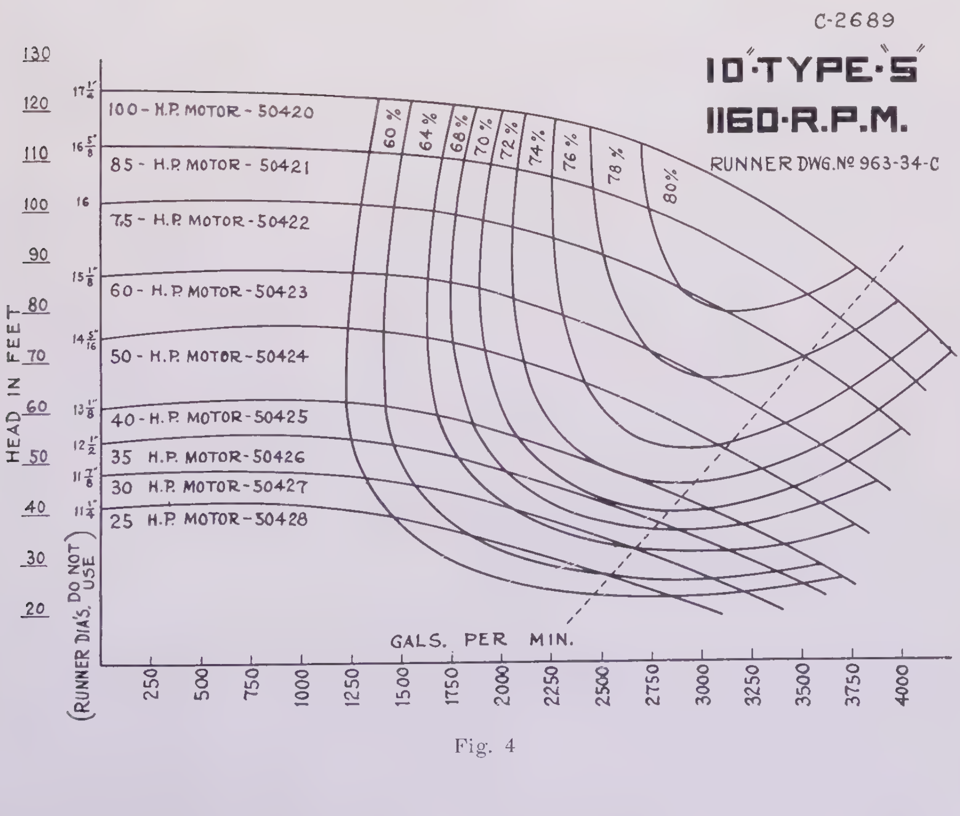
C-2689
10" TYPE "S"
1160-R.P.M.
RUNNER DWG. № 963-34-C
100 - H.P. MOTOR - 50420
85 - H.P. MOTOR - 50421
75 - H.P. MOTOR - 50422
60 - H.P. MOTOR - 50423
50 - H.P. MOTOR - 50424
40 - H.P. MOTOR - 50425
35 H.P. MOTOR - 50426
30 H.P. MOTOR - 50427
25 H.P. MOTOR - 50428
60%
64%
68%
70%
72%
74%
76%
78%
80%
HEAD IN FEET
(RUNNER DIA'S. DO NOT USE)
GALS. PER MIN.

Fig. 4

above. The Brake Horsepower calculated for the point where the curve crosses the dotted line is the maximum value and indicates the greatest load which the pump can put on the motor under any conditions.

As variable speeds are not usually available on installations of motor-driven centrifugal pumps, the capacity can only be regulated by throttling either the suction or discharge connections. Partially closing either the suction or discharge valves increases the head and reduces the capacity in accordance with the characteristic curves. For pumps with a suction lift the total head change obtainable by throttling the suction is small. It is, therefore, better to do the necessary regulating on the discharge side.

The most progressive builders design and manufacture their pumps so that in each case they may be arranged to fit the exact conditions under which they may operate, to the best advantage. To accomplish this, the impellers are all cast to maximum size. On receipt of definite information as to operating conditions, the impeller is turned down to the exact size required, thus giving a choice of an almost unlimited number of runner sizes. This practice results in the highest possible efficiencies being obtained in each case. The charges against a centrifugal pump installation consist of a small amount for fixed charges and a relatively large amount for current. For this reason, high efficiencies have a greater effect on total costs than for other types when fixed charges are proportionally a much greater part of the total. It frequently happens that a few per cent better efficiency will easily justify a considerable difference in price.

Motor-driven centrifugal pumps except in very large sizes are usually shipped completely assembled on their common base plates. Although it is a comparatively simple matter to install them, it is very important that the aligning be very carefully done. A flexible coupling is usualy furnished between the pump and the motor, but this is only intended to take up motion horizontally and any misalignment is bound to interfere with proper operation and result in a short life for the coupling and excessive bearing loads. Great care must also be taken that the suction and discharge pipes are properly supported.

Although a centrifugal pump will operate with as high a suction lift as any other type, very high suction lifts are to be discouraged as a small leakage of air will interfere seriously with the capacity of the pump and may cause it to lose its suction entirely. Wherever possible water should not be raised to the pump over fifteen feet, as above that point there is a falling off in capacity. Where the water pumped is hot, as in the case of boiler feed, the suction lift possible is still further reduced and for temperatures above 170° F. there should be a positive suction head.

Unlike the displacement type, a centrifugal pump is not self-priming. It is essential, therefore, that it be entirely filled with water before it is started. On account of the small clearances between running and stationary parts operation for a very short time unprimed may cause serious damage. The method of priming depends on local conditions. The most common are by means of an independent vacuum pump, an ejector or a foot valve. The latter method should be avoided when possible as a foot valve is a frequent source of trouble and puts additional friction losses in the suction line, which should be as short and direct as possible and of ample size.

Centrifugal pumps can be divided into two classes, single stage and multi-stage. Owing to its much greater simplicity the single stage pump should be used wherever possible, unless due to unusual conditions a multi-stage pump can be supplied which will be sufficiently more efficient to warrant the higher cost. Frequently, the use of two or more single stage pumps in series will give a very satisfactory high head installation. Owing to continual improvement in design the heads for which single stage pumps can be obtained for efficient operation have been continually increased until now they are recommended for heads as high as 300 feet in the smaller sizes and up to about 200 feet for very large sizes. The single stage pump has the big advantage of being of the double suction type and is consequently automatically balanced. For multi-stage pumps it is necessary to provide some means of taking the unbalanced thrust and for this purpose the automatic hydraulic balancing disc has been found to be extremely satisfactory.

For ordinary conditions the closed runner type of pump has been found the most satisfactory and efficient. However, where water containing solids or grit is to be handled, the open runner type is preferable owing to its tendency to clear itself of obstructions and being less subject to wear.

Along with the many mechanical improvements in design of centrifugal pumps, efficiencies obtainable today are far in excess of what was thought possible a few years ago. Efficiencies as high as 86 and 87 per cent are now common, and these efficiencies are maintained over quite a wide range in operating conditions.

From being a cheap and inefficient machine that was only justified in unusual conditions, the centrifugal pump has come to be recognized as an efficient and valuable auxiliary in manufacturing processes and as a means of pumping liquids, which, due to its simplicity, is well worth serious consideration.

Non-Condensing Electric Generators*

By J. H. Grainger

In discussing this subject it is necessary, on account of the brief time and space allotted, to touch upon only the most important points to be considered in arriving at a conclusion as to which type of prime mover is best suited to meet the requirements for sugar mill service. Doubtless the practice in the sugar factories in Hawaii, as regards the several types of prime movers used for this service, is generally characteristic of the other cane sugar producing countries. Here we have the following types of prime movers driving generators, and operating with initial pressures ranging from 80 lbs. to 150 lbs. saturated steam and exhausting to back pressures ranging from 0 lb. gage to 10 lbs. gage:

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* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

Steam turbines;
Corliss engines;
Poppet valve engines;
Uniflow engines.

There are, of course, a number of slide valve and piston valve engines driving small generators, but for generators 300 k. w. and larger, these four types of prime movers doubtless cover the field. And to go still further, it is perhaps safe to say that at least 85 per cent of the total sugar mill generator capacity in Hawaii is either steam turbine or Corliss engine driven.

Expansion of Steam

Since the days of Watt, the economy of using steam expansively has been fully recognized and has perhaps reached its ideal in the steam turbine operating with the highest possible initial steam pressure, and the lowest possible vacuum on the exhaust.

The effort is to obtain the maximum number of expansions with a minimum amount of internal condensation. The releasing valve gear of Corliss gave us the desired range of expansion for prevailing steam pressures, and the compound and other multiple expansion engines later reduced the internal condensation by dividing the range of temperature among a number of cylinders instead of having it all occur in one.

The steam turbine through its ability to utilize a high degree of vacuum carries the expansion of steam to its practical limit, and due to the fact that each row of blades is operating at practically a constant temperature, internal condensation is minimized.

However, the steam turbine is not, under ordinary pressures, as economical as the reciprocating engine, the records for thermal efficiency still being held by reciprocating pumping engines, the superiority of the turbine lying in its ability to utilize higher pressures and temperatures than is practical with reciprocating engines.

Corliss Engines

The Corliss engine is one in which the point of cut-off is controlled by a governor acting directly through a releasing valve gear.

For a period of forty years, and until superseded by the steam turbine, this type of engine was the recognized American standard for economy, durability and general excellence.

The ordinary semi-rotative Corliss valve actually is a "D" slide valve made in four pieces, so that each cutting edge is separately adjustable, with the additional advantage that the point of cut-off is variable without affecting the other functions of the valves.

This type of valve is balanced as soon as moved off the lap, but unbalanced and held tightly to the seat when closed, and due to the use of a "wrist plate" motion, the valves have practically no movement when in the closed and unbalanced position.

The criticism has been made that a valve of this type soon leaks, due to wear, but this is entirely erroneous, because while the valve is a complete cylinder, it is intended to fit only a small segment of the cylinder, and the two surfaces wear parallel to each other, and the valve remains tight almost indefinitely, and engines which have been in service for more than forty years are today making as good indicator diagrams as when new.

The Corliss engine is limited in speed, due to the releasing valve gear, to between about 100 r. p. m. for the very largest sizes, to 150 or even 175 r. p. m. for the smallest sizes.

Owing to the rubbing surfaces which must be lubricated, the Corliss valve is limited to a maximum steam pressure of about 175 lbs., and to a total temperature of about 500° F., but for any pressure of 175 lbs. or under, or any steam temperature up to 500° F., the Corliss engine is equal in economy, and superior in durability to any other type of reciprocating steam engine.

Poppet Valves

Poppet valves are usually of the double seat type, and being practically balanced and having no sliding surfaces, are suitable for higher pressures and temperatures than Corliss valves. For pressures above 175 lbs., or temperature above 500° F. either poppet valves or balanced drop piston valves should be used. The principal objections to poppet valves are that they are difficult to keep tight, as their expansion is affected by temperature; they are exceedingly delicate of adjustment; and the cams with which they are operated require great skill in manufacture, and careful attention in operation. In brief, for ordinary speeds, pressures and temperatures, Corliss engines will be found fully as economical as the poppet valve engines, and much easier to maintain. They also require less skilled operators.

It is evident therefore that there is nothing to be gained by the use of poppet valve engines with comparatively low initial steam pressures and temperatures and high back pressures such as prevail in sugar factories.

"Uniflow" Engines

In the "Uniflow" engine, the effort is to obtain a high number of expansions with a minimum amount of internal condensation. In compound or other multiple expansion engines, these results are accomplished by dividing the expansion, and consequently the range of temperature between two or more cylinders. The expansions are usually about twice as many as would be used on a simple engine of the Corliss type, or about half as many as would be employed in a compound engine operating with the same steam pressure.

To prevent the initial condensation which would ordinarily result from the short cut-off, high compression is used to restore the heat to the clearance space, and consequently also the cylinder head is steam jacketed as well, so that the incoming steam does not meet any cold surfaces.

The Uniflow engine partially accomplishes the results aimed at, its economy under proper conditions being measurably greater than that of a simple engine

operating with less expansions, but inferior to that of the compound engine operating with a greater number of expansions.

Clearance volume in a cylinder is recognized as the greatest obstacle to high economy, and, therefore, the Uniflow engine is most economical when operating with a high degree of vacuum, because with such a vacuum the clearance may be kept low without danger of compression running above the initial steam pressure.

For non-condensing conditions, however, and particularly where back pressures are employed, as in process work, the Uniflow engine shows no superiority in economy, because with atmospheric or higher back pressures, the clearance volume must be made very large in order to prevent over compression; or auxiliary exhaust valves must be employed which brings the machine down to the economy of the four-valve class with the added disadvantages of the Uniflow cylinder and piston construction.

The name Uniflow is really a misnomer, because after the point of cut-off in a cylinder, there is no "flow" of steam, but an expansion in all directions; and when the exhaust port is opened, it is entirely immaterial whether the steam rushes out at the center of the cylinder or at the end. But there is, it is true, some advantage, in that the piston covers the cold exhaust port at the time steam is admitted.

Due to the fact that a single cylinder engine responds quicker to the governor than does a compound engine with a receiver, the Uniflow engine, if operated condensing, is well adapted for service where the load fluctuations are severe, as in rolling mill work; but for fairly steady loads, the compound engine is superior in economy at no greater first cost; while for the non-condensing or back pressure conditions, the simple Corliss engine is superior and has a considerably lower first cost.

Incidental objections to the Uniflow engine are the general objections to poppet valve gear, but more particularly to the difficulties of lubrication, especially where high pressures and temperatures are employed.

Compound and Multiple Expansion Engines

The employment of compound or other multiple expansion engines is determined by the operating conditions, chief among these being steadiness of load.

Non-condensing compound engines have about the same economy as simple condensing engines, and are usually employed either where water is not available for condensing, or where the exhaust is desired for process work. The non-condensing compound engine has a comparatively narrow range of load capacity, depending on the back pressure employed. The compound condensing engine may be employed to advantage in all cases where the load is reasonably steady, for while it will take care of wide variations in load, its best economy is at an average predetermined load. The triple or (quadruple) expansion engine can only be employed to advantage where the loads are quite steady and known at the time the machinery is designed, such load conditions occurring principally in pumping engines, and marine engines on ships making long voyages.

The use of such engines for fluctuating loads or for short periods is of no economic advantage, and of considerable mechanical disadvantage, and the same remarks apply to steam turbines.

Steam Turbines

The steam turbine is essentially a heat engine, and due to the fact that there are no rubbing contacts within the cylinder, with the consequent necessity for internal lubrication, it is better adapted mechanically to utilize much higher steam pressures and temperatures than are considered practical for reciprocating steam engines.

A steam turbine when operating condensing carries approximately 50 per cent of its load in the low pressure stage where the entering steam pressure, under ordinary conditions, is usually less than the pressure required for process work. It is evident, therefore, that we cannot expect as good steam economy from the turbine when operating against back pressure in the exhaust, as can be realized with a Corliss engine with a variable cut-off controlled by the governor.

The steam turbine has a decided advantage over any other type of prime mover for process work, in that it requires no internal lubrication, and consequently there is no lubricating oil to contend with in the exhaust steam.

The turbine also in practice uses less lubricating oil for the bearings, inasmuch as it is usually equipped with a self-contained lubricating and filtering system which permits of using the oil over and over again with practically no loss.

As compared with a reciprocating engine of the same capacity, the turbine requires somewhat less space and foundation work, and is therefore cheaper to install.

On the other hand, it is very necessary in turbine operation to maintain more constant steam pressures for satisfactory operation, and to see that the turbine is furnished with dry steam, free from acid or gas-forming impurities, such as are almost unavoidable in sugar factories at times.

General

Let us assume the following steam conditions:

Initial Pressure	125 lb. gage
Back Pressure	10 lb. gage

These conditions involve such a limited number of expansions that they are best met in an economical and practical way by the use of a simple engine. In fact at about 20 lbs. back pressure there is no difference in economy between Simple, Compound and Uniflow engines—they will reach a common point—and from the standpoint of steam economy, the turbine lags far behind.

Fig. 1 illustrates the above point. The upper diagram illustrates the expansion in an ideal engine without clearance, which shows that you would have five and one-half expansions to just reach a terminal of 10 lbs. back pressure, and that a 22″ steam cylinder would be required to deliver 420 k. w. at point of best economy at 900′ piston speed.

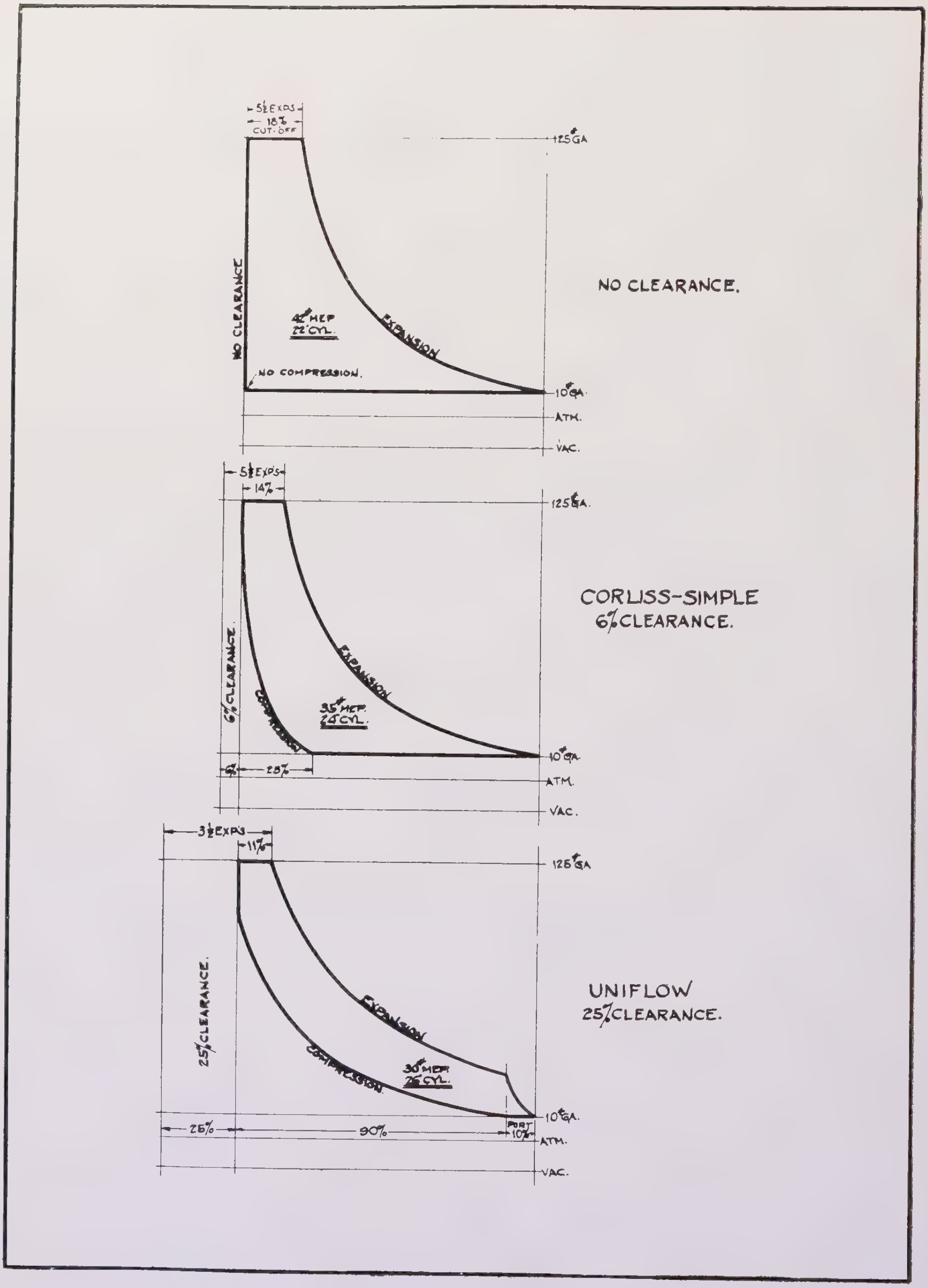

Fig. 1

The center diagram is for a simple Corliss engine with 6 per cent clearance and shows that five and one-half expansions with a 14 per cent cut-off would give an expansion line just reaching a terminal pressure of 10 lbs., and this would require a 24″ cylinder to do the same work as the theoretical 22″ cylinder shown in the upper diagram.

The lower diagram is for a Uniflow engine, which in order not to have the compression run above the boiler pressure, would require a clearance of about 25 per cent (or the use of auxiliary exhaust valves which are only used when an engine must run both condensing and non-condensing), and we would get a cut-off of about 11 per cent with three and one-half expansions, for, if we made a greater number of expansions, the cut-off would be so short that the indicator diagram would be exceedingly small, and the size of the cylinder abnormally large. On the same basis of speed as the simple Corliss engine the Uniflow would require a 26″ cylinder.

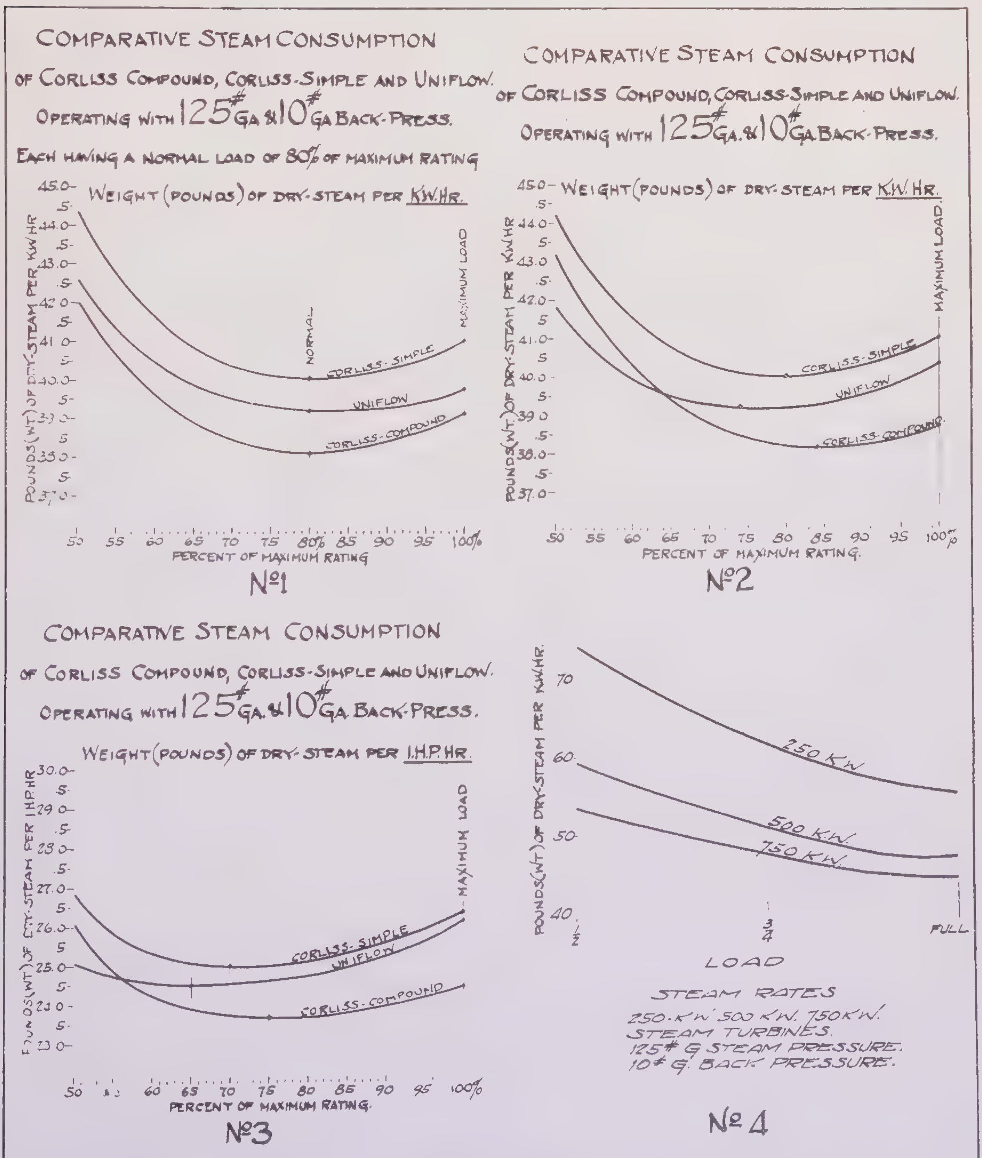

Fig. 2

A compound engine would make the same number of expansions as the simple Corliss, i. e., five and one-half, but they would, of course, be divided between the two cylinders.

Steam Economy

No. 1, Fig. 2, shows the relative steam economy of the simple Corliss, the Uniflow and the Corliss compound *based on their point of maximum economy* being at 80 per cent of the full load, the Corliss figures being from standard curves, while the Uniflow is taken from the best information obtainable from all sources, and, if anything, represents a better condition than would ordinarily obtain.

No. 2, Fig. 2, shows the relative steam consumption per *k. w. hr.* of the three types of engines *as usually rated;* that is, with the simple Corliss giving its best economy at 80 per cent load, the Uniflow at 74 per cent, and the compound Corliss at 84 per cent. These curves take into account the generator efficiency at the varying loads, and, therefore, represent the economy of the unit.

No. 3, Fig. 2, gives the relative steam consumption per *i. h. p. hr.* of the three types of engines, and indicates that the most economical point for the simple Corliss is 70 per cent of the maximum load, of the Uniflow 65 per cent, and of the Compound 75 per cent.

These curves have all been made on the basis of a 500 k. w. maximum rated unit, but there would be no substantial difference for either a 250 k. w. or 750 k. w.

No. 4, Fig. 2, shows the approximate steam rates of 250 k. w., 500 k. w. and 750 k. w. steam turbine per k. w. hour from half load to full load.

Sizes and Prices

The following table gives the cylinder sizes, r. p. m., best load (most economical point), steam per k. w. at point of best economy, and price f. o. b. works of 250, 500 and 750 k. w. maximum rated units in simple Corliss, compound Corliss and Uniflow types. The factory price for the three sizes of steam turbine is also given. The figures for the simple Corliss engines, compound Corliss engines and steam turbines are based on Allis-Chalmers Mfg. Co. standard data, while the Uniflow engine figures are taken from the best informaton available.

COMPARISON OF SIMPLE CORLISS, COMPOUND CORLISS AND UNIFLOW ENGINES OF 250, 500 AND 750 K. W. (MAX. RATED, STEAM 125 LBS. SATURATED) 10 LBS. BACK PRESSURE

		A	B	C
	Max. Rating	250 K. W.	500 K. W.	750 K. W.
	Cylinder	16″ x 36″	22″ x 36″	26″ x 42″
	R. P. M..............	150	150	120
Simple	Best Load............	200 K. W.	400 K. W.	600 K. W.
Corliss	Steam per K. W. Hr....	40 Lbs.	40 Lbs.	40 Lbs.
	Price at Works	$10,000.00	$13,000.00	$19,000.00

	Cylinders	14″ & 22″ x 36″	18″ & 28″ x 36″	22″ & 36″ x 42″
	R. P. M.	150	150	120
Compound	Best Load	210 K. W.	420 K. W.	630 K. W.
Corliss	Steam per K. W. Hr.	32.2 Lbs.	38.15 Lbs	38.05 Lbs.
	Price at Works	$14,500.00	$18,000.00	$26,000.00
	Cylinder	18″ x 30″	28″ x 36″	32″ x 42″
	R. P. M.	180	150	125
Uniflow	Best Load	185 K. W.	370 K. W.	560 K. W.
	Steam per K. W. Hr.	39.25 Lbs.	39.2 Lbs.	39.15 Lbs.
	Price at Works	$15,000.00	$22,500.00	$33,000.00
Turbine	Price at Works	$11,000.00	$15,000.00	$19,000.00

Tasseling*

By O. C. Markwell

In order to avoid confusion, this subject will be treated in the following manner:

1. Tasseling of mature or second season canes.
2. Tasseling of immature or first season canes.
3. Influencing factors.

Tasseling of Mature Canes

The tasseling of mature canes is desirable or undesirable in so far as it increases or decreases the yield of sugar. It is supposed that tasseling affects the juices. If this is true, then the percentage of canes which tassel during the second season is a figure to be considered. With the above supposition in mind, W. C. Jennings offers the following data, which he secured at Hawi Mill and Plantation Company:

JUICE ANALYSIS OF TASSELED AND UNTASSELED CANE, FIELD HOEA 9
SAMPLES GROUND IN HAND-MILL AND ANALYZED

January 8, 1924

Sample		Brix	Pol.	Pur.	Q. R.
D 1135	Tasseled	16.4	13.83	84.3	9.76
	Untasseled	15.2	12.87	84.7	10.51
Yellow Caledonia	Tasseled	18.6	16.51	88.7	7.98
	Untasseled	19.1	17.16	89.9	7.66
H 109	Tasseled	16.4	14.05	85.7	9.57
	Untasseled	15.8	13.73	86.9	9.7

* Presented at Third Annual Meeting of Association of Hawaiian Sugar Technologists, Honolulu, October 27, 1924.

		Brix	Pol.	Pur.	Q. R.
Striped Mexican	Tasseled	18.7	16.92	90.5	7.73
	Untasseled	18.6	17.31	93.06	7.43

The H 109 tasseled so heavily and the Yellow Caledonia so lightly that it may detract somewhat from the value of comparisons in these varieties.

March 16, 1924

Sample		Brix	Pol.	Pur.	Q. R.
D 1135	Tasseled	18.8	16.79	89.3	7.85
	Untasseled	18.9	16.30	86.3	8.23
Yellow Caledonia	Tasseled	20.8	18.93	91.	6.89
	Untasseled	20.9	19.29	92.3	6.69
H 109	Tasseled	20.1	18.65	92.8	6.92
	Untasseled	19.7	18.93	96.	6.72
Striped Mexican	Tasseled	19.8	19.01	96.	6.68
	Untasseled	19.6	18.93	96.5	6.70

April 26, 1924

Sample		Brix	Pol.	Pur.	Q. R.
D 1135	Tasseled	20.0	18.22	91.1	6.51
	Untasseled	19.8	17.71	89.3	6.63
Yellow Caledonia	Tasseled	19.6	17.48	89.1	6.70
	Untasseled	20.9	18.74	89.6	6.28
H 109	Tasseled	21.1	20.05	95.0	6.05
	Untasseled	20.7	19.82	95.7	6.15
Striped Mexican	Tasseled	20.9	19.29	92.3	6.18
	Untasseled	20.4	19.99	97.9	6.19

For D 1135 there is a consistent beneficial effect, while with Yellow Caledonia the opposite is true. This data does not give sufficient evidence to enable one to draw a definite conclusion.

The following counts were made in five different locations in Field Hoea 9 to determine the percentage of tasseling. Only the inside lines were counted, taking the third, thirteenth and twenty-third in a watercourse in each locality:

H 109

Line No.	Total Stalks	Total Tasseled	Total Untasseled	Percentage of Tassels	Remarks
1	39	36	3	92	3 very thin stalks not tasseled
2	77	72	5	94	5 smaller than average stalks not tasseled
3	74	67	7	91	5 very thin stalks not tasseled, 2 larger but still below average
4	63	59	4	94	1 very thin and 2 smaller than average not tasseled
5	78	70	8	90	All thin stalks
6	93	86	7	93	5 very thin and 2 smaller than average
7	103	102	1	99)	
8	89	88	1	99)	Untasseled stalks smaller than average
9	109	107	2	98)	

10	91	88	3	97	3 thin stalks
11	91	82	9	90	7 very thin and 2 near average
12	79	70	9	89	6 small and 3 near average
13	84	79	5	94	Untasseled stalks all thin
14	87	82	5	94	1 very thin and 4 below average
15	92	85	7	92	6 small and 1 near average
Per cent of tasseled stalks......				93	

Every line in two watercourses was inspected, but no stalks that had not tasseled were found which approached the average in size.

The following counts were made in the third and thirteenth lines of a watercourse in six different locations in Field Hoea 9:

Striped Mexican

Line No.	Total Stalks	Total Tasseled	Total Untasseled	Percentage of Tassels	Remarks
1	76	65	11	86	3 small stalks, 8 below average in size, 7 very small
2	98	86	12	88	3 below and 2 average stalks, 8 very small
3	104	85	19	82	11 below average, 4 very small
4	69	60	9	87	2 below and 3 average, 2 very small
5	82	74	8	90	2 below average
6	91	79	12	87	12 below average, 5 very small
7	97	83	14	86	9 below average
8	83	77	6	93	6 below average, 7 small
9	107	89	18	83	11 below average, 1 small
10	96	88	8	92	7 below average, 5 small
11	87	76	11	87	7 near average
12	93	86	7	92	5 near average, 2 small
13	86	77	9	90	8 below average, 1 small
Total...	1169	1025	144	88	

In the Striped Mexican quite a large percentage of stalks had evidently started to arrow and then stopped. No further growth takes place at the tip and the interior of the sheath is dead. These stalks are counted as having tasseled.

The following counts were made in the third line of a watercourse in five different locations in Field Hoea 9:

D 1135

Line No.	Total Stalks	Total Tasseled	Total Untasseled	Percentage of Tassels	Remarks
1	92	86	6	94	1 small, 5 average circumference stalks
2	89	81	8	91	5 small, 3 average circumference stalks
3	111	95	16	86	8 very small, 8 below average circumference stalks
4	106	87	19	82	6 small, 13 below average circumference stalks
5	101	90	11	89	11 all below average circumference stalks
Total....	499	439	60	88	

In both D 1135 and H 109 untasseled stalks are, as a rule, either very small in circumference, or have subnormal appearing stalks or large suckers. The suckers, or any stalks which are apparently second season growths, are disregarded in making counts.

The tables showing the percentage of tasseling, which Mr. Jennings presents, contain some interesting remarks. While they do not settle the question, they emphasize the necessity of further endeavor along this line.

In the following data, supplied by Richard Penhallow, it is interesting to note that there is a big difference in the amount of tasseling among the standard varieties under different environment. Count was made at the end of December, 1923:

Striped Mexican

Field No.	Plant or Ratoon	Percentage of Tassel	Remarks
3	Ratoon	27	Mauka
4	"	63	"
5	"	57	" (1st ditch, lower)
5	"	32	" (2nd ditch, upper)
6	"	34	"
86	"	45	"
86	"	50	"
86	"	43	"
24	Plant	51	"
3	Ratoon	57	"
3	"	50	" Inside valley
13	"	2	" Tasseled heavily last year
14	"	57	"
16	"	39	Ordinary elevation
41	"	60	" "
67	Plant	70	" "

H 109

Field No.	Plant or Ratoon	Percentage of Tassel	Remarks
6	Ratoon	35	Mauka
38	Plant	59	"
38	"	53	"
39	Ratoon	43	"
43	"	44	"
9	"	36	Makai
31	Plant	41	Ordinary elevation
31	"	76	Very heavy cane along bank of stream
31	"	79	Makai
99	Ratoon	30	Ordinary elevation, rainfall slight
40	"	51	" "
42	Plant	41	" "
56	Ratoon	40	" "
57	"	29	" "
55	Plant	64	Makai
60	Ratoon	50	"

		Lahaina	
95	Ratoon	33	Makai, heavy cane
95	"	Few	Poor spot
95	"	20	Makai, good cane
95	"	35	Ordinary elevation, fair cane
95	"	50	" " very good cane
66	"	61	" "
		Yellow Caledonia	
7	Plant	5	Mauka
8	Ratoon	5	"
7	Plant	5	"
8	Ratoon	5	"
		H 146	
6	Ratoon	20	Mauka
9	"	14	Makai
20	"	19	Ordinary elevation
		D 1135	
13	Plant	16	Mauka, light stand
67	"	36	Ordinary elevation, good stand
		Badila	
31	Plant	2	Ordinary elevation
		Wailuku 3	
31	Plant	2	Ordinary elevation, good cane
		Wailuku 6	
31	Plant	11	Ordinary elevation, good cane

Tasseling of Immature or First Season Canes

Tasseling of immature or first season canes is undesirable because it decreases the yield. Cut-back experiments should prove or disprove this for any given variety and locality. Into our cut-back experiments has entered a factor which some think has worked to the disadvantage of cutting back. This will be discussed under influencing factors.

Varieties: The time of tasseling and the length of time required to mature their seed differ with the varieties.

In general, of our standard varieties, H 109 and D 1135 are the highest in tasseling percentages, while Yellow Caledonia and Striped Mexican are comparatively light. H 146 is our earliest tasseler, although it does not mature its seed as quickly. Badila comes in flower among the late ones, and H 5001 seldom tassels. However, Richard Penhallow says that at Wailuku it was observed tasseling in November, after less than a year's growth.

He also made the following comparisons as to the time of the year different varieties tassel:

Wailuku, Maui, Ordinary Elevation, November 3, 1923

D 1135—tasseling in all fields.
Lahaina—tasseling in some fields.
Striped Mexican—a few tassels in some fields.
H 109—a few tassels in some fields.
Wailuku 4, 13, 5 and 11—very few tassels.

Richard Penhallow states that Wailuku 22 never tassels. Some Hawaiian canes are said to never flower. From observation and what can be learned from the older residents of Kauai, the Hawaiian variety, Puaole, does not tassel.

It should be comparatively easy to classify varieties and seedlings according to their general habits of tasseling. It might be well to consider such a classification where tasseling should be avoided.

Influencing Factors

Relative to observations on factors influencing tasseling, you will note the remarks and notes attending the data of W. C. Jennings, which he summed up by saying: "In both D 1135 and H 109 untasseled stalks are, as a rule, either very small in circumference, subnormal appearing stalks, or large suckers."

The above observations are partially corroborated by Richard Penhallow, who says:

In the middle of November I made counts in three varieties and recorded them as follows:

Variety	Per cent Tassel	Remarks
W 5	2.4	Mauka line where growth was short
W 5	8.2	
W 5	17.7	Mauka line where growth was exceptionally long
W 5	25.5	
W 5	19.6	Mauka line—short growth.
W 5	43.0	Makai line—heavy growth
W 9	8.75	Normal line in hollow
W 9	4.5	Growth retarded by nut grass
W 9	34.6	Mauka line—very heavy growth
W 9	1.2	Mauka line—poor stand
W 9	1.14	Good growth
W 9	32.9	Very heavy growth

In Wailuku 4 a few tassels were noticed where growth was very heavy, but none on the pali where growth was poor.

In a gulch at McBryde Sugar Company, differences in the time and amount of tasseling of Yellow Caledonia, ratoons, were noted as follows:

A—High pali, protected from wind, practically unirrigated, only two or three tassels appeared.

B—Bottom of gulch, heavy cane, most mature, had sufficient water. Tasseled earlier and heavier, about 15 per cent.

C—Pali, wind swept. At time of tasseling of "B" about 5 per cent tasseled. As late as February more tassels appeared. Total 10 per cent.

Of the above data, Richard Penhallow says:

The cane had very good growth for its age. The fact that the cane grew so fast shows that a great deal of vigor was in the plants. When growing conditions became adverse, this vigor had to be turned to something else and the cane, already large enough, turned it to producing seeds.

No doubt the difference in amount of tasseling in the above observations is due to environment. Of environment's role in tasseling W. W. G. Moir writes:

I feel reasonably certain from observations and data secured from many varieties under different environmental treatment that the greatest factors in preventing severe tasseling, in the susceptible varieties, and none in the very slightly susceptible ones, are regularity and uniformity of environment at least three months prior to the regular tasseling period. This regularity may be good or poor agricultural practice as long as it is uniformly carried out from beginning to end and not a mixed practice.

Examples of this may be cited here: A field of H 109 harvested at an elevation of 800 feet in January was neglected entirely until July 1 when it was weeded, fertilized and irrigated. At that time half of the field was cut back, and had regular uniform treatment up to tasseling time. The area which was not cut back tasseled only 8 per cent and had about 30 tons of cane per acre, while the cut-back cane with no tasseling had less than 5 tons of cane per acre.

There were far more shoots per line in the non-cut-back, but they had not the strong appearance that would bring them through to maturity. There is another process going on at this stage in the growth of both the cut-back and the non-cut-back cane, which will be discussed later, which tends to even up the yield for a period of the growth.

Here we have given a case where the treatment of the crop was what you would call poor agricultural practice (neglect). The neglect was uniform and regular, that is, at no time was the place given any agricultural treatment of any kind until regular and uniform plantation work could start—5 months after harvesting.

In another field at a little lower elevation (in general), the lower the elevation the less tasseling in H 109 as observed under conditions here (Maui), the H 109 was harvested at the same period, but was prepared for the next crop immediately by weeding, irrigating and fertilizing, but due to the lack of a willing contractor the agricultural practice was irregular, the periods between irrigations varying from 12 to 30 days. This continued up to tasseling time. The percentage of tasseling was around 30 per cent. In an adjoining field a piece of H 109 was harvested about the same time, but not treated, practically neglected, except for weeding. Yet it tasseled only 10 per cent.

In still another field the H 109, harvested at the same time but taken up, was given regular plantation treatment in regular and uniform doses. Here the process continued regularly throughout the crop and less than 5 per cent tasseling was recorded.

So we can feel reasonably certain from these cases, together with several other corroborative experiments or observation inserts, that the prime factor influencing tasseling is environment, and that we secure heavier tasseling with irregular environment and practically none where the environment is kept either uniformly severe or uniformly good.

Mr. Moir continues to explain his stand on cutting back as previously referred to:

As mentioned above, I said there was a tendency to equalization of yield in both the cut-back and non-cut-back areas. In cutting back a crop you are starting it all over

again and its rate of growth becomes much more rapid than does a crop that has been stunted and neglected. This difference in rate of growth continues until the second season growth starts. The cut-back area may appear to surpass the non-cut-back for a period, but beginning with the second season a "grand reawakening," as you might call it, happens to the non-cut-back area. Extremely great numbers of large, strong, secondary shoots appear. These are so numerous and strong that one wonders how so many stalks may find room in a line to grow. From then on if your growing conditions are ideal enough, the non-cut-back area will far out yield the cut-back, even though they at one time became equalized.

Mr. Moir believes that "extra" tasseling along the watercourse is due to lack of uniform environment, while Penhallow thinks that it is due to the additional growth of the cane, which in turn is due to environment.

At any rate there may be some basis for the criticism of our present cut-back experiments.

F. W. Broadbent, Maui, says:

It appears to me thus far that unless fields of ratoons can be given a proper start soon after harvesting, it is more profitable to cut them back later, and start them off. An argument based on tassel percentage is not too sound because the stand of the no-cut-back stuff is not up to that which has been cut back.

He suggests cut-back experiments as follows:

1. No-cut-back cane that is started soon after harvest.
2. No-cut-back cane that is started per plantation schedule.
3. Cut-back cane started per plantation schedule.

In January, 1924, marked differences in tasseling were noted in two experiments at Koloa Sugar Company. These experiments were located in Field 51 in the mauka section, elevation about 600 feet. Upon investigation the following data were obtained:

Experiment 17—Amount of Reverted Phosphate, 1925 Crop—Yellow Tip Cane, Planted April, 1923—Tassels Counted January 22 and 23, 1924

A— 500 pounds of reverted phosphate per acre.
B—1000 pounds of reverted phosphate per acre
C—1500 pounds of reverted phosphate per acre
D—None

Tassel Count

Plots	Average per Row Tassels	Average per Row Sticks	Percentage
A	38.5	215	19.25
B	18.75	234.5	8.00
C	18.25	235	7.76
D	61.5	184.25	33.7

For the first few months phosphate did not appear beneficial. Subsequently, however, canes of "B" and "C" plots showed marked gains. In nearby experiments, Field 51, no response to nitrogen or potash is visible.

No doubt there is a high mortality of sticks in the no-phosphate plots, for it was observed during the tassel count that many of the small sticks were dying.

In Experiment 14, Plant Food, Field 51, tassel counts were made and the data secured corroborates the results of the tassel count of Experiment 17.

Experiment 14—Plant Food—Yellow Caledonia, Planted March, 1923

Plots	No. of Plots	Average per Row Tassels	Average per Row Sticks	Per cent Tasseling
N	5	5	99	5.05
NP	5	3	116	2.58
NK	5	6	102	5.88
NPK	5	3	111	2.7
PK	5	2	122	1.64

All plots which received phosphate had 1,000 pounds reverted per acre in furrow before planting.

The writer interprets the above results as indicative that the heavy tasseling of the canes of the A (500) and D (none) plots was due to stunting, which in turn was due to marked unavailability of the plant food element, phosphorus. He believes that in a soil showing a strong response to nitrogen or potash, similar results would be obtained.

Blind Eyes

Inquiries were made relative to the cause and occurrence of blind eyes. Most observers associate their occurrence with tasseling. The few long joints below a tassel have no eyes. It has been noted that blind eyes correspond to the tassel season. It has been suggested that the blind eyes are formed by the same influence which causes tasseling, but that the influence is not strong enough to cause tasseling, so normal growth is resumed when eyes again form.

Concerning blind eyes, A. D. Shamel asserts that there is some evidence involving the terrific competition under which canes labor.

Executives Want to Save Dollars, Not Heat Units*

In the industrial plant, the operating engineer often feels that the factory management regards the power plant as a necessary evil, something to be put up with for want of a better method of turning the wheels in the production departments, but something on which no money is to be spent except in a case of dire necessity. The plant engineer feels this most keenly when he approaches the management with a request for new equipment that will raise the efficiency of his boilers and engines. He finds that the management often has little patience with his troubles and he cannot understand why, because his needs are so evident to himself.

* Power Plant Engineering, Vol. XXVIII, No. 24.

The reason for his apparent lack of interest will be clear when we consider that the executive thinks in terms of business and finance, not engineering. He thinks of the total cost of the factory's product, of first costs, interest on investment; fixed charges, depreciation and the like. If he is not an engineer himself, the executive thinks of the power plant simply as a place from which to obtain as cheaply as possible the power necessary to turn the wheels of the production departments.

Yet this very attitude taken by so many executives gives the engineer a chance to show the management that here in the power producing department is an opportunity to cut costs that has too often been overlooked. The principles of good salesmanship apply here. The proper stand for the engineer to take is that the question is one of business policy, that by investing a definite amount of money in equipment carefully selected to decrease the fuel consumption and pay for itself within a definite time, a material reduction can be made in the cost of supplying power. An approach to this subject from this viewpoint will arouse the instant attention of the executive, whereas the recital of technical woes often leaves him cold.

It goes without saying that in presenting his case in this way, the engineer will be prepared to prove his point, like any other good salesman. For example, if he needs a new feed-water heater, he can find out without much trouble how much the heater will cost, the depreciation on it, the cost of maintenance, the interest on the investment, and the fuel saving that will result from its use. Then he can show how in a definite time, considering past averages, the saving will pay for the heater and how, after that time, the power cost will be reduced by just that much, allowing, of course, for the replacing of the heater at the end of its life.

In attempting to raise the efficiency of his plant, the engineer can secure the interest and co-operation of the management if he will remember that they are primarily interested in saving dollars, not heat units or power units. Without too much trouble, he can translate his technical information into business terms. When he does this, he finds that, after all, the management is interested in his work.

[Keep the boiler or power plant clean and neatly painted. Cleanliness in a plant promotes pride, and pride in one's work means better and more careful work.]

[W. E. S.]

Sugar Prices

96° Centrifugals for the Period March 17, 1925, to June 18, 1925

Date	Per Pound	Per Ton	Remarks
Mar. 17, 1925	4.755¢	$95.10	Cubas, 4.77; Porto Ricos, 4.74.
" 18...........	4.71	94.20	Porto Ricos.
" 19...........	4.74	94.80	Cubas.
" 25...........	4.71	94.20	Cubas.
" 26...........	4.68	93.60	Porto Ricos.
" 30...........	4.65	93.00	Porto Ricos.
" 31...........	4.62	92.40	Cubas, 4.65; Philippines, 4.59.
April 1...........	4.59	91.80	Porto Ricos.
" 7...........	4.52	90.40	Porto Ricos.
" 8...........	4.535	90.70	Porto Ricos, 4.52, 4.55.
" 9...........	4.52	90.40	Porto Ricos.
" 14...........	4.505	90.10	Cubas, 4.52, 4.49.
" 15...........	4.445	88.90	Porto Ricos, 4.43, 4.46.
" 16...........	4.40	88.00	Cubas.
" 22...........	4.385	87.70	Porto Ricos, 4.40, 4.37.
" 27...........	4.40	88.00	Cubas.
" 28...........	4.365	87.30	Cubas, 4.33, 4.40.
" 29...........	4.315	86.30	Cubas, 4.33; Porto Ricos, 4.30.
" 30...........	4.27	85.40	Cubas.
May 1...........	4.33	86.60	Cubas.
" 12...........	4.365	87.30	Porto Ricos, 4.33; Cubas, 4.40.
" 13...........	4.43	88.60	Cubas, 4.40, 4.46.
" 14...........	4.315	86.30	Cubas, 4.33; Porto Ricos, 4.30.
" 18...........	4.30	86.00	Porto Ricos.
" 19...........	4.285	85.70	Cubas, 4.30; Philippines, 4.27.
" 20...........	4.27	85.40	Philippines.
" 23...........	4.33	86.60	Porto Ricos.
" 25...........	4.365	87.30	Porto Ricos, 4.33; Philippines, 4.40.
" 26...........	4.43	88.60	Porto Ricos, 4.40; Cubas, 4.43, 4.46.
" 27...........	4.41	88.20	Porto Ricos, 4.46, 4.37; Cubas, 4.40.
" 29...........	4.37	87.40	Cubas.
June 2...........	4.43	88.60	Cubas, 4.40, 4.46.
" 4...........	4.445	88.90	Porto Ricos, 4.46; Cubas, 4.43.
" 10...........	4.40	88.00	Porto Ricos.
" 16...........	4.46	89.20	Cubas.
" 18...........	4.43	88.60	Porto Ricos.